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EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF COLD-FLOW THROUGH THE TURBINE OF THE SPACE-SHUTTLE MAIN ENGINE HIGH-PRESSURE FUEL TURBOPUMP

by

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Computational predictions and experimental measurements were made on the Naval Postgraduate School's cold-flow turbine test rig. The test turbine was the Space-Shuttle Main Engine, High-Pressure Fuel Turbopump, Alternate Development Model, designed and manufactured by Pratt & Whitney. The flow-field around the first-stage rotor end-wall region was measured using a laser-Doppler velocimetry (LDV) system. Measurements were taken at two axial locations over the rotor blade tip and at three radial locations from the end-wall casing. Three circumferential velocity profile measurements were taken downstream of the first-stage using a three-hole pressure probe. All measurements were taken at a referred rotational speed between 4781 and 4904 rpm. A computational fluid dynamics model of the combined first-stage stator and rotor was developed. Predicted velocity data from this model were extracted for comparison to the rotor exit plane probe measurements.

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EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF COLD-FLOW THROUGH THE TURBINE OF THE SPACE-SHUTTLE MAIN ENGINE HIGH-PRESSURE FUEL TURBOPUMP

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ABSTRACT

Computational predictions and experimental measurements were made on the Naval Postgraduate School's cold-flow turbine test rig. The test turbine was the Space-Shuttle Main Engine, High-Pressure Fuel Turbopump, Alternate Development Model, designed and manufactured by Pratt & Whitney. The flow-field around the first-stage rotor end-wall region was measured using a laser-Doppler velocimetry (LDV) system. Measurements were taken at two axial locations over the rotor blade tip and at three radial locations from the end-wall casing. Three circumferential velocity profile measurements were taken downstream of the first-stage using a three-hole pressure probe. All measurements were taken at a referred rotational speed between 4781 and 4904 rpm. A computational fluid dynamics model of the combined first-stage stator and rotor was developed. Predicted velocity data from this model were extracted for comparison to the rotor exit plane probe measurements.

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I. INTRODUCTION

A. PURPOSE

This thesis describes experimental flow field measurements in the first-stage turbine rotor end-wall of the Space Shuttle's Main Engine (SSME) High-Pressure Fuel TurboPump (HPFTP). It also describes the generation of a combined turbine stator and rotor computational fluid dynamics model. Comparisons were made between the experimental measurements and the numerical predictions of the rotor exit plane flow field.

B. OVERVIEW

With the advancement of computers in the past decade, advanced viscous flow fields can be computed within a reasonable period of time. The use of computational fluid dynamic (CFD) codes can save money and time in the development of turbomachines. With the help of these codes more efficient blade shapes can be designed to decrease aerodynamic losses and heating. Such designs can result in longer service life and lower operational costs of the gas turbine engine.

The Naval Postgraduate School's Turbopropulsion Laboratory (TPL) has been supplied with the Alternate Turbopump Development (ATD) model of the SSME HPFTP, designed by Pratt & Whitney. In Figure 1, a schematic of the SSME from Sutton [Ref. 1: 1992], the HPFTP is depicted on the left-hand side of the diagram. This device consists of a two-stage, axial flow turbine. The turbine is driven by the flow of hydrogen gas and steam, which is the product of the combustion of hydrogen and oxygen. The turbine in turn drives a 3-stage hydrogen pump. The HPFTP was designed to operate at an inlet temperature and pressure of 1900 degrees Rankine (°R) and 5200 pounds per square inch (psia), while developing

73,000 horsepower (hp) at a rotational speed of 40,000 revolutions per minute (rpm).

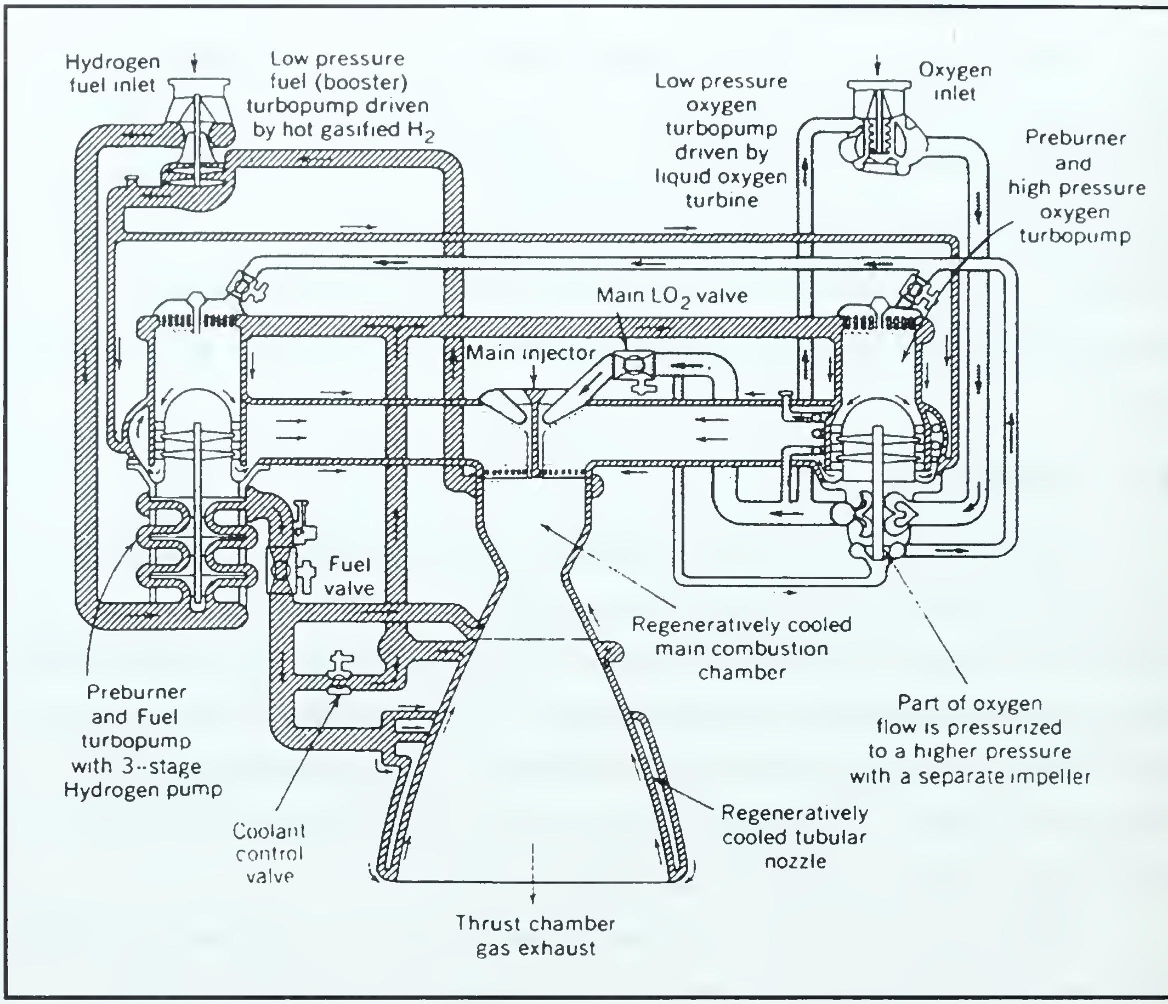


Figure 1. The Space-Shuttle Main Engine

The HPFTP has been modified for the Turbine Test Rig (TTR) to facilitate LDV measurements for the purpose of validating viscous flow codes. Several students have undertaken this project. The first was Studevan [Ref. 2: 1993] who initially designed and installed the cold-flow test facility. Rutkowski [Ref. 3: 1994] redesigned parts of the bearing housing and was responsible for the initial numerical modeling of the turbine stator. Greco [Ref. 4: 1995] further modified the TTR, adding the

data acquisition system, and continued the numerical analysis of the first stage stator and rotor. Southward [Ref. 5: 1998] redesigned the layout of the TTR to accommodate the LDV system and performed the first LDV measurements in the turbine.

1. Experiment

The ultimate goal of this research was to collect LDV measurements to validate Computational Fluid Dynamics computer models of the cold-flow immediately adjacent to the end-wall of the turbine in the first-stage rotor tip clearance region. LDV measurements were taken at three axial positions with three radial depths for each axial position. Cobra probe surveys at three circumferential positions were also taken at the first-stage rotor exit plane.

2. Numerical Simulation

Three different numerical simulations were conducted. The flow field of the first-stage stator was investigated using RVC3D (Rotor Viscous Code 3-D) [Ref. 6: 1992], and using SWIFT [Ref. 7: 1997]. The combined first-stage stator and rotor flow fields were investigated using the SWIFT code. Two grid generation programs were used. The stator and rotor grids were first developed in TCGRID (Turbomachinery C-Grid) [Ref. 8: 1990] and later developed in TCGRID version 202 [Ref. 9: 1996], which is compatible with the SWIFT code.

3. Past and Ongoing Research

Several studies on computational studies of flow through turbines and LDV measurements in tip clearance areas have been conducted over the past few years. Most recently Ameri, Steinthorsson and Rigby [Ref. 10: 1998] used computational models to study the effect of tip clearance and casing recess on heat transfer and stage efficiency in axial turbines. However they only computed a rotor flow field without an upstream stator

and presented their numerical predictions without comparison to any experimental data. Stahlecker and Gyarmathy [Ref. 11: 1998] conducted 3-D LDV measurements while investigating turbulent flow in a centrifugal compressor vaned diffuser. This study is the most recent in the ongoing effort to acquire three-dimensional LDV measurements in turbomachines. For a more complete list of references pertaining to turbomachinery LDV measurements, particularly those in turbines, refer to Southward [Ref. 5: 1998].

II. EXPERIMENTAL SETUP

A. TEST FACILITY AND HIGH-PRESSURE FUEL TURBOPUMP TURBINE

The Naval Postgraduate School's High Speed Turbopropulsion Laboratory (TPL) was the site of all testing done on the High Pressure Fuel Turbopump (HPFTP). The cold-flow Turbine Test Rig (TTR) was driven by compressed air supplied by an Allis-Chambers compressor. A schematic of the air supply system is shown in Figure 2 and the compressor is shown in Figure 3.

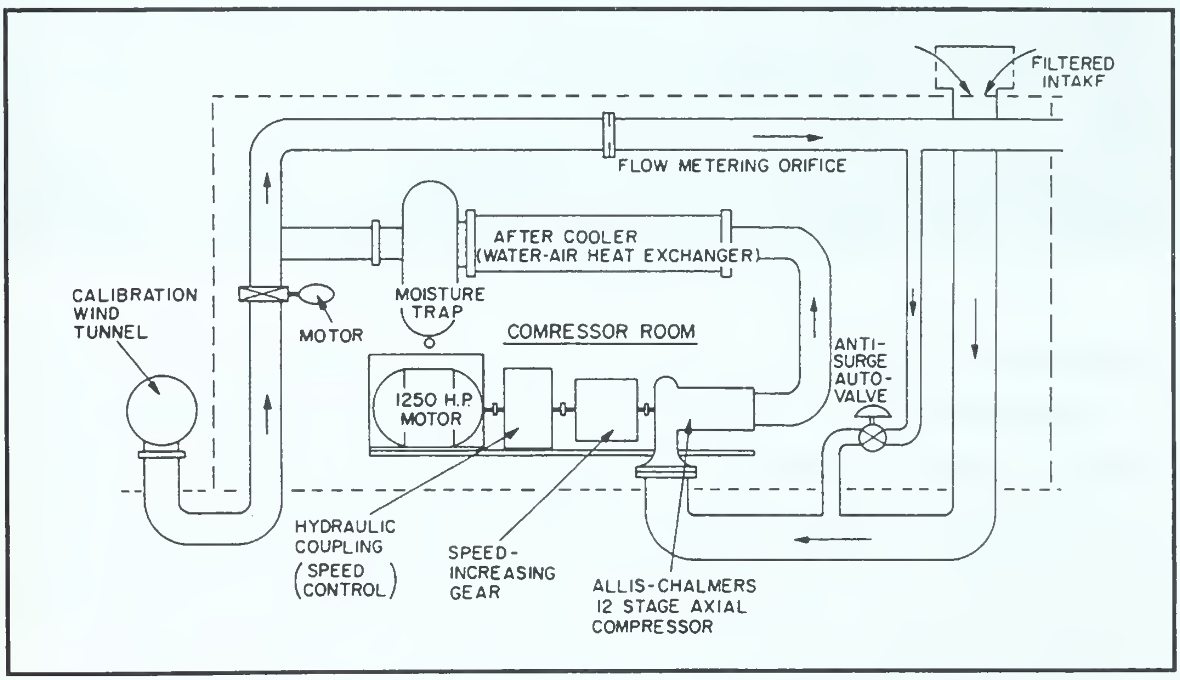


Figure 2. Schematic of Allis-Chalmers 12 Stage Axial Compressor

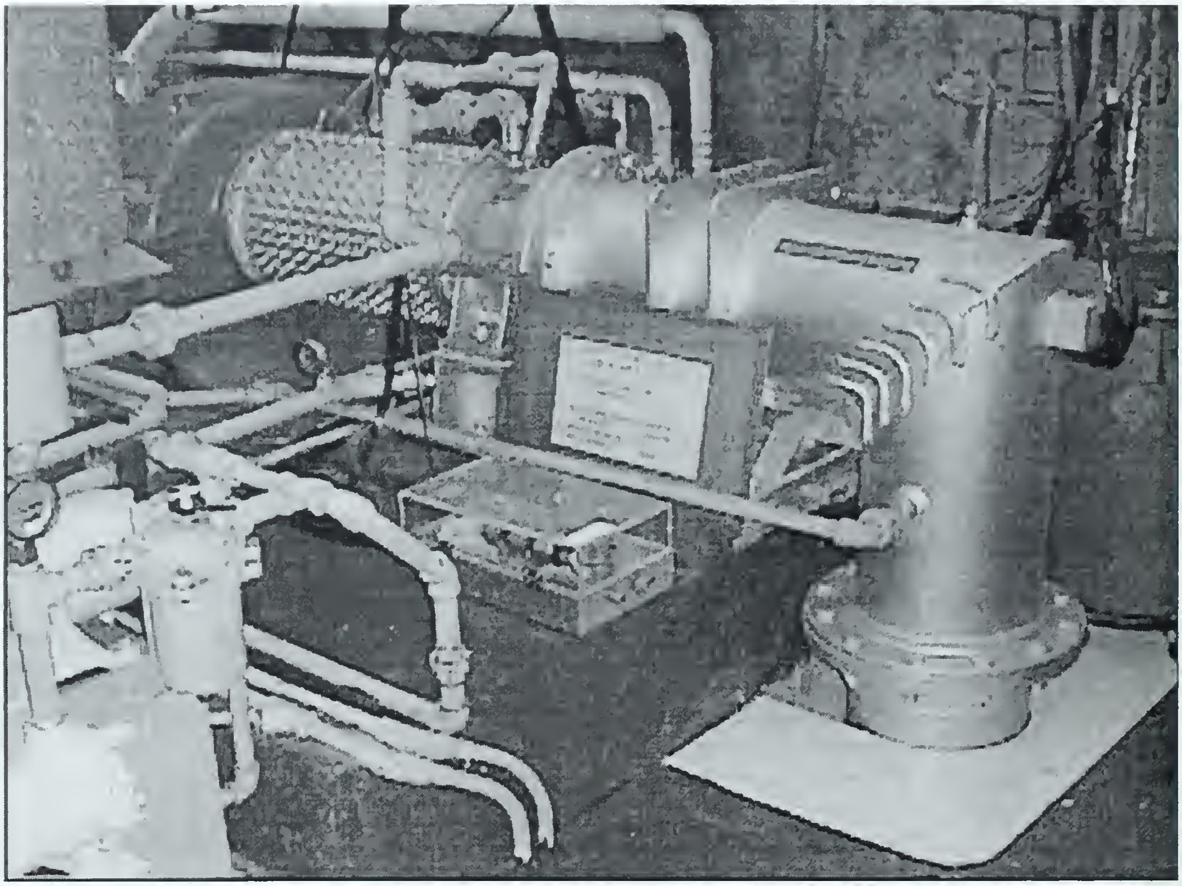


Figure 3. 12 Stage Axial Compressor

Compressed air was routed to the test cell through large pipes. The flow of compressed air to the test cell was controlled using one in-line and two dump valves, which were adjusted manually at a console outside the test cell (Figure 4). The test cell itself housed the Turbine Test Rig (TTR), laser-Doppler velocimetry (LDV) system and Scanivalve. A schematic of the TTR is shown in Figure 5 and depicted in Figure 6. The bearing housing was rebuilt after bearing failure and the throttle guide rod, movable back pressure plate and shaft cover were removed for ease of maintenance.

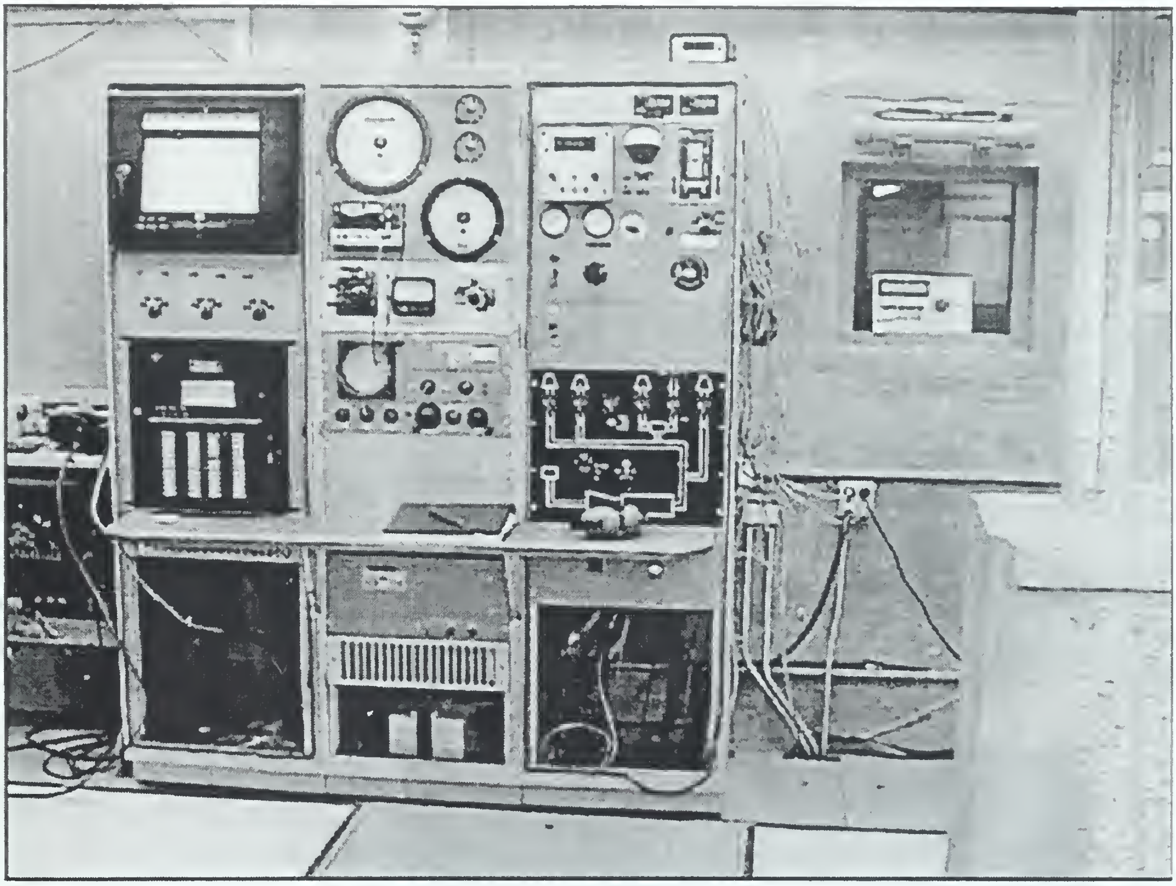


Figure 4. Photo of Dump-valve Controlls for Compressed Air Control

The data acquisition system was housed in the main room of the TPL. Two personal computers (PCs) were used, one to collected data from the TTR and the other collected data from the LDV system. Figure 7 shows the layout of the test cell. For a detail description of all experimental equipment refer to Southward [Ref. 5: 1998].

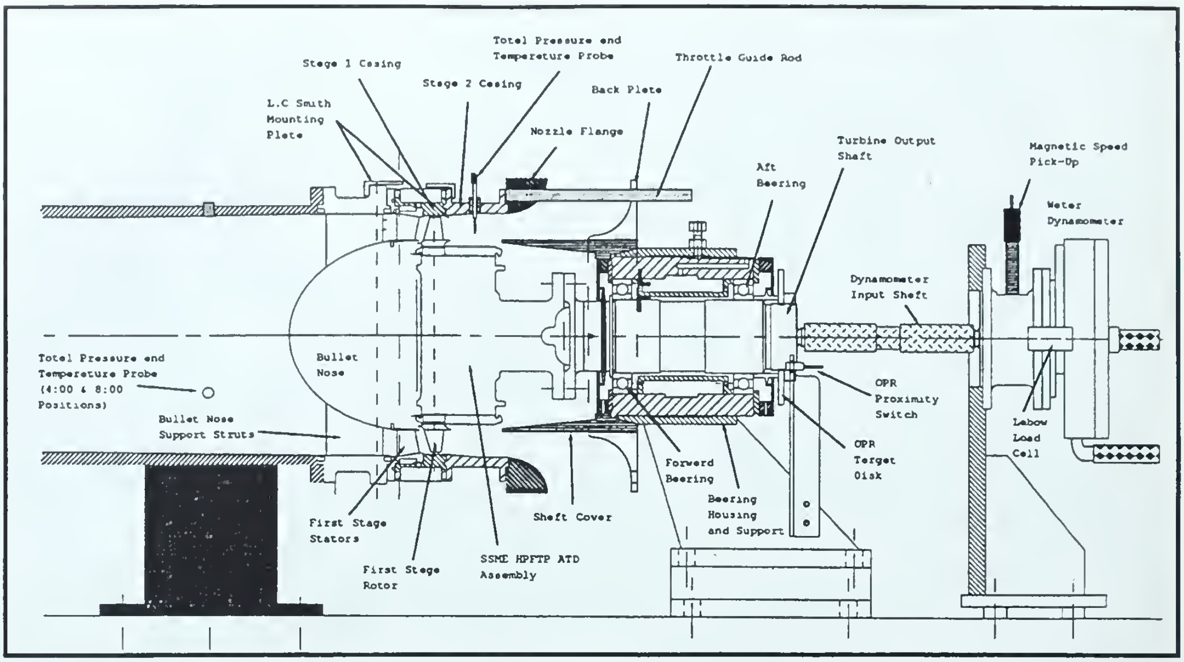


Figure 5. Schematic of the Turbine Test Rig

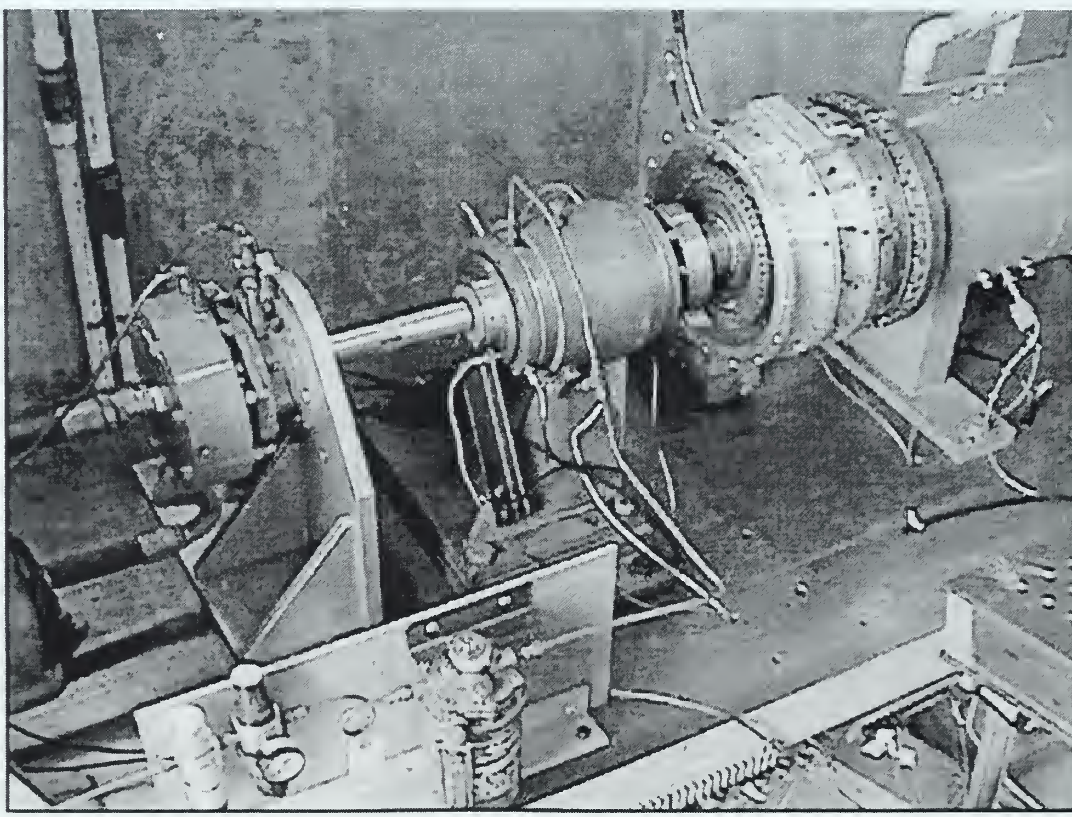


Figure 6. Photo of Turbine Test Rig

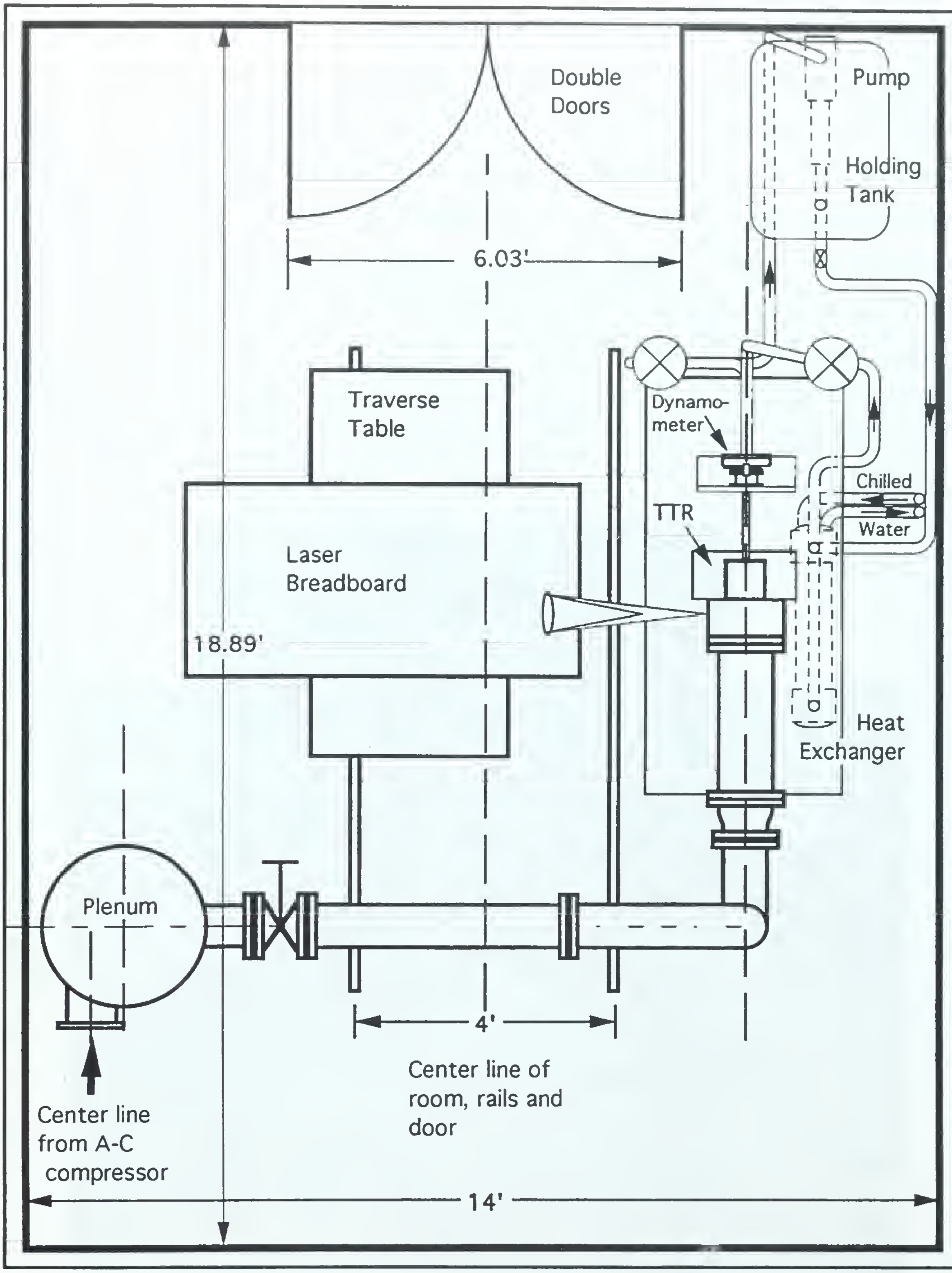


Figure 7. Turbine Test Rig Test Cell, from Ref. [5]

B. COBRA PROBE SETUP

A three-hole (Cobra) pressure probe was used to measure total pressure, Mach number and flow angle at three circumferential positions of the first-stage rotor exit plane. The Cobra probe's radial and yawing movements were controlled from the main room of the TPL using a control box which housed a DC-to-AC power converter and the actuators for the Motion system. The three-hole probe was inserted through an access hole and attached to the TTR using a mounting plate. The access hole was adjusted to the three survey sites by detaching the aft portion of the TTR and rotating it to the desired position and then reattaching. Figure 8 shows the Cobra probe attached to its calibration stand.

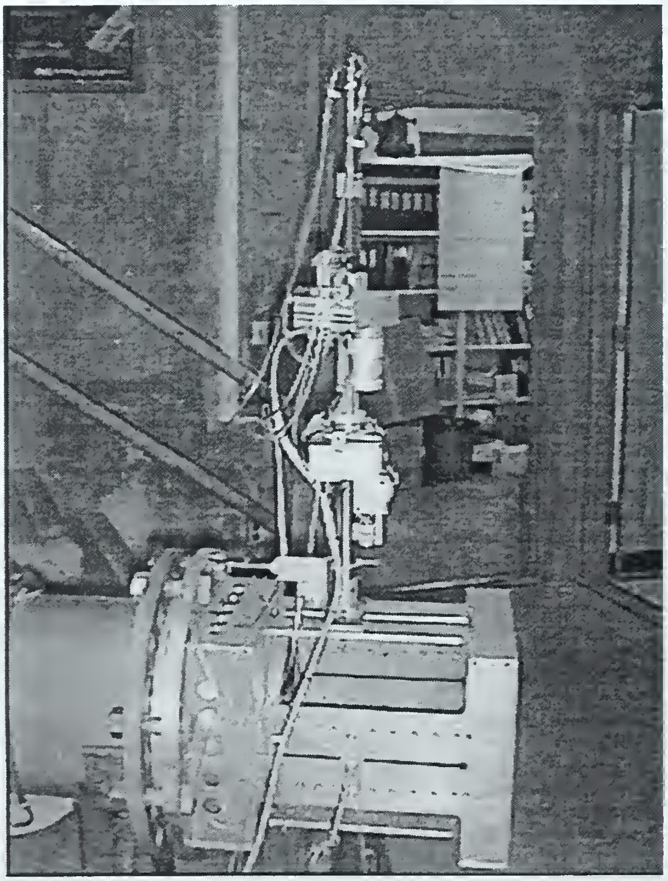


Figure 8. Cobra Probe Mounted on Calibration Stand

Two pressure transducers were connected to the probe. The center hole was connected to a single transducer and used for total pressure

measurement. The two outboard ports were connected to either side of a single differential pressure transducer. The Cobra probe and associated pressure ports were connected to a Scanivalve by plastic tubing. This tubing was replaced with more ridge plastic tubing to correct the pressure lag discovered in previous experiments.

C. LASER DOPPLER VELOCIMETRY SETUP

The LDV system was set up to measure the axial and circumferential components of flow in the TTR's first-stage rotor end-wall region. An argon-ion laser and associated optics were mounted on a traverse table system (Figure 9). The green and blue beams produced by the laser were split and one side of each beam was sent through a frequency shifter before being focused inside the TTR observation port. The frequency shifters were found to be faulty and sent out to be recalibrated.

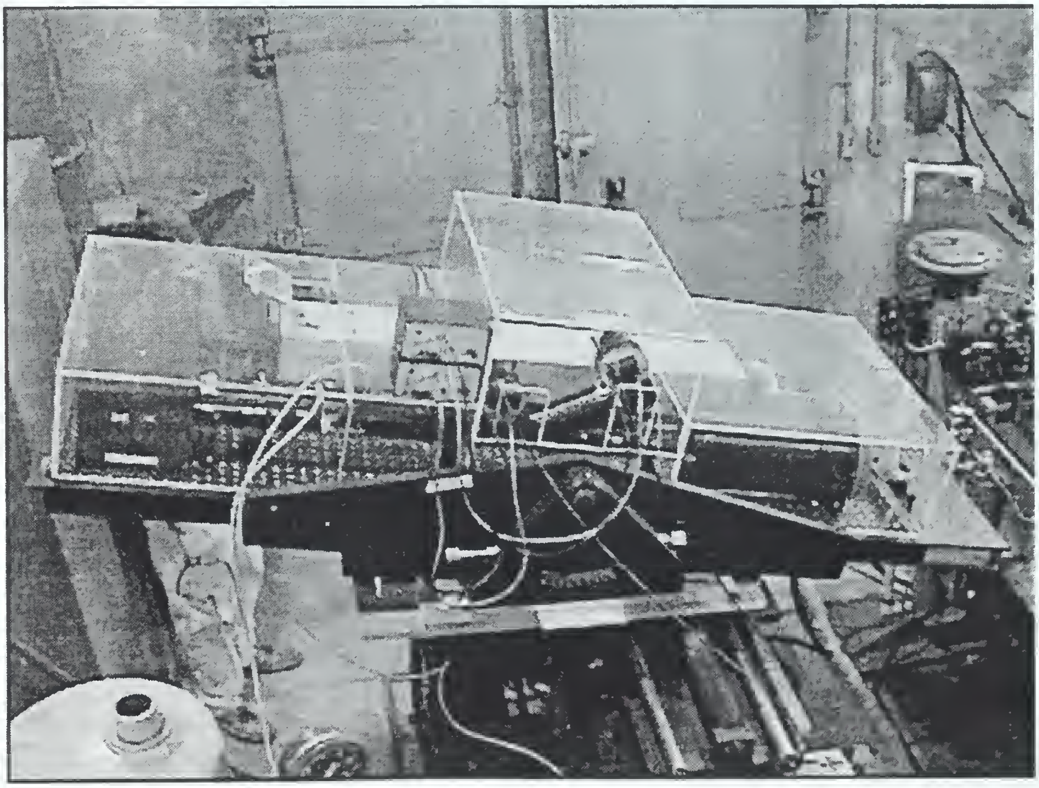


Figure 9. Laser and Optics on Traverse Table

Two six-jet atomizers were used to seed the flow with anhydrous glycerin. The seeding material was introduced into the flow with a modified wand far upstream and adjacent to the wall (Figure 10). The seeding wand was redesigned to introduce the seeding particles closer to the turbine wall for better seeding density. The interference of the laser beams produced fringes. The reflected light, produce by the seeding particles passing through the fringes, was collected through receiving optics by two photomultipliers. The signals from the photomultipliers were sent to an IFA750 for correlation with the once per rev output of the rotating machinery resolver. A TSI parallel interface card, mounted in a 386 personal computer (PC), collected the information from the IFA750. Phase Resolved Software version 2.06 was used to analyze the data collected from the IFA750.

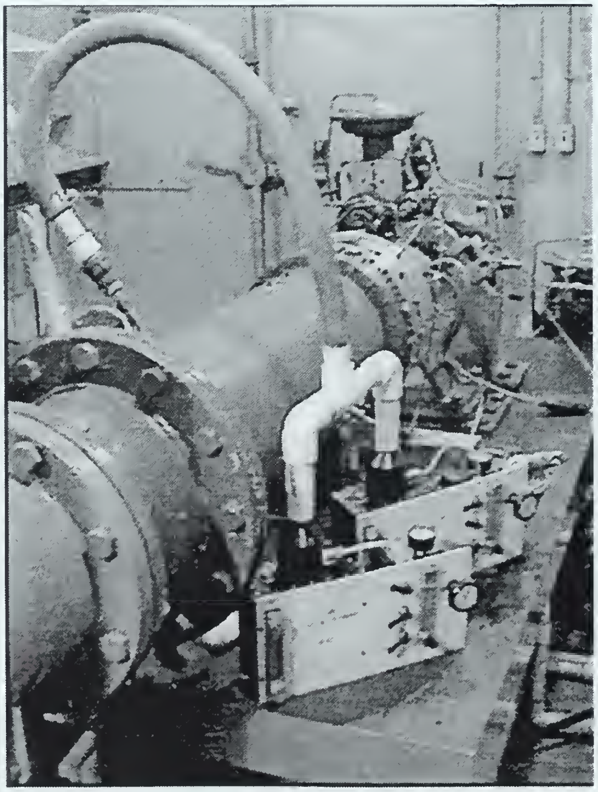


Figure 10. Two Six-Jet Atomizers

D. TTR DATA ACQUISITION

The TTR data acquisition system was located outside of the test cell in the lower portion of the control room (Figure 11) and consisted of a 486 PC with interface boards, Signal Conditioner Unit (SCU), and three Hewlett-Packard data acquisition modules. The Scanivalve was located in the test cell (Figure 12). Data acquisition was controlled by a LabView Software Package. For a detailed description of each component refer to Southward [Ref 5: 1998].

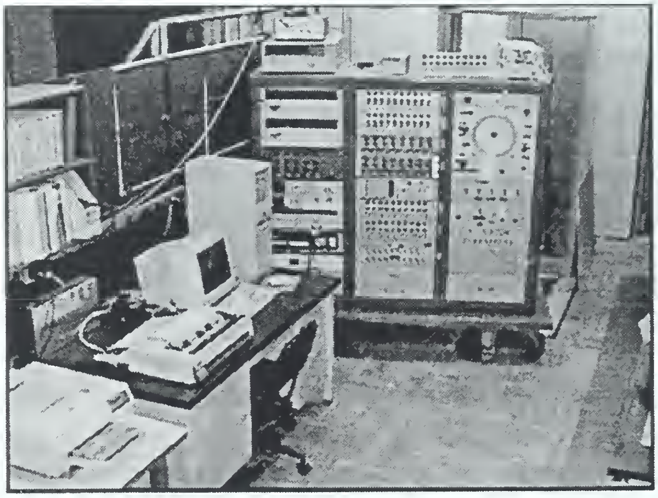


Figure 11. Data Acquisition System

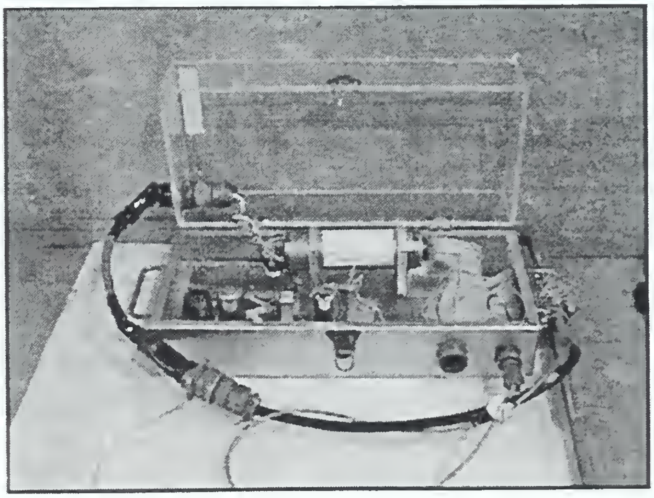


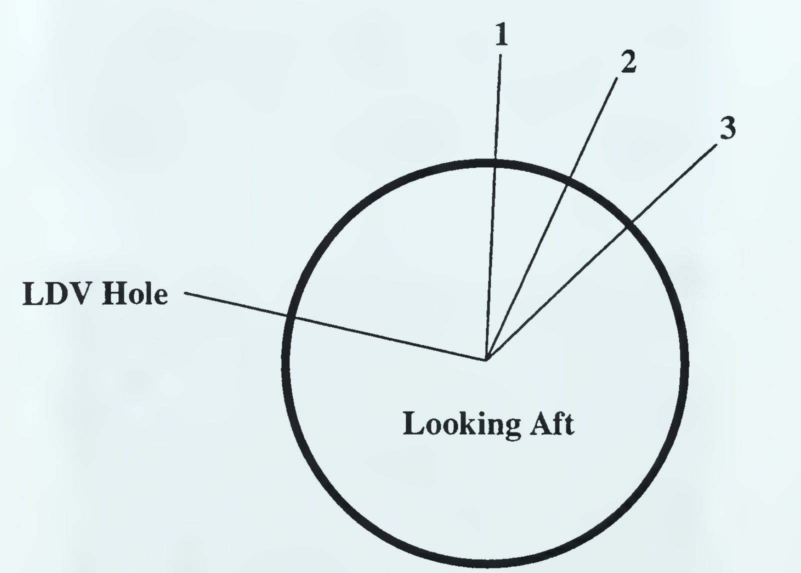
Figure 12. Scanivalve

E. EXPERIMENTAL PROCEDURE

Two different experiments were conducted on the TTR. After the replacement of the bearings in the bearing housing, Cobra probe surveys were conducted at three circumferential locations in the rotor exit plane. LDV measurements were then conducted in the end-wall region of the first-stage rotor.

1. Cobra Probe Measurements

A three-hole pressure probe was used to measure the exit flow conditions of the first-stage rotor. Exit total pressure, flow angle and Mach number were measured. The probe was located .31 inches aft of the rotor tip trailing edge. Four complete surveys were conducted from the end-wall to the hub at three circumferential positions, with two taken at position 2. Figure 13 shows the circumferential position of the surveys.



Positon	degrees from LDV Hole
1	67.33°
2	90.27°
3	113.03°

Figure 13. Positions of Cobra Probe Survey

Set up of the three-hole pressure probe is described in Southward [Ref. 5: 1998, pgs 44-45]. Probe depth was monitored by the LabView program ACTUATOR.VI and controlled by a switch box which was manually operated from the control room's data-acquisition station. After setting the probe to the desired depth the flow angle was determined by nulling the signal from the differential pressure transducer. The probe was rotated left or right until the out-board pressures were equal. This was indicated by a near zero read-out from the digital volt meter (DVM).

After nulling was accomplished, the data acquisition program VEL_PRFL.VI was run to collect pressure and temperature readings from the various probes on the TTR. The program then calculated and displayed Mach number. The VEL_PRFL.VI program produced an output file named VEL_PRFL.DAT. The data from this file were extracted and plotted with the Microsoft Excel program. Probe surveys were first conducted at position 2 (Figure 13). The probe was then removed and the aft casing rotated to position 3. The pressure probe was then reinstalled. Each time the probe was removed, care had to be taken in order not to scrape the probe against the walls of the access port. After completion of the survey at position 3, the probe was moved to positions 2 and 1 for surveys at each. The probe was then removed from the TTR.

2. LDV Measurements

All LDV measurements were taken close to the first stage rotor end-wall. Southward [Ref. 5: 1998, pgs 41-54] reported procedures for start-up, shut-down, and positioning of the LDV systems. LDV surveys were taken at the first two axial locations (Table 1).

Axial Position	1	2	3
Tip chord (c_t)	**-0.16**	**0.35**	**0.84**
Distance from center LDV hole (inches)	**.125**	**0**	**.125**

Table 1. Axial Position of LDV holes

Three radial depths were surveyed at each axial location. Table 2 lists the depths, in inches from the end-wall and percent span of the rotor, for each radial location.

Radial Position (% Span of rotor)	Distance from Outer casing end-wall
98	**0.0187**
93	**0.0688**
88	**0.1190**

Table 2. LDV Radial Positions

After the laser was moved to the desired location for measurements, the circumferential laser beam was shifted by 10MHz to eliminate blade backscatter and the outputs from both photomultipliers were observed using the PHASE resolve software running on a PC. Appendix I of Southward [Ref. 5: 1998, pgs 131-132] lists the menu settings for the PHASE resolve software. All settings were identical with the exception of the Automatic Filter Selection, which was 5-30 MHz for both channels. The PHASE software enabled the data to be taken every 0.1°. First-stage rotor blades were spaced every 7.2°, equating to 50 blades. Data were taken every 0.1° around the first-stage rotor at the forward axial position. The data acquisition window for the center axial position was adjusted to blank out passage of the blade through the probe volume. Again, data

were taken around the full 360° of the rotor, but only at positions between the blades.

Data were reduced using the PHASE resolve software. All the bins of data were combined into one blade passage. For the forward axial position the bins were averaged into 72 bins, corresponding to one bin every 0.1°. The center axial position was window-averaged into 30 and 18 bins, equating to 3.0° and 1.8° respectively. The output files from the data reduction were then converted to a usable format using the "Phase3.for" Fortran program modified by Southward [Ref. 5: 1998]. Data were then plotted using the Microsoft Excel program.

III. COMPUTATIONAL FLUID DYNAMICS

A computational fluid dynamics (CFD) model was constructed to simulate the flow through the first-stage of the SSME HPFTP ATD for the purpose of comparing experimental results with the numerical model. The geometry of the first stage stator and rotor were obtained by Greco [Ref. 4: 1995]. Greco produced the first-stage stator and rotor grids using Turbomachinery C-Grid (TCGRID), [Ref. 7:1990]. The flow was then simulated using Rotor Viscous Code 3-D (RVC3D), [Ref. 6: 1992]. The stator and rotor models were run separately through RVC3D.

The purpose of this study was to run the stator and rotor together using a new program under development by Dr. Chima of NASA Lewis Research Center (LERC) called SWIFT, [Ref. 9: 1997]. This new program allows for multiple grids to be combined and rotated with respect of one another.

A. MODIFIED STATOR GRID GENERATION

The old version of TCGRID was used to develop the modified stator grid. Since there was no surviving data on disk of Greco's original stator, the data were scanned and an optical character recognition (OCR) program was used to convert the scanned image into editable text. This text was then compared to the original and errors in the text corrected. Greco's stator grid was then modified to model a step in the end-wall casing just aft of the stator (Figure 14). The height of the step was represented by ten grid points and this distance was represented by multiple radii to curve the edges of the step. The new wall was then edited into the "stator.in" file for input into TCGRID. The output from TCGRID was then run with RVC3D and SWIFT to compare the results of the two CFD programs. Appendix A shows the results of these runs.

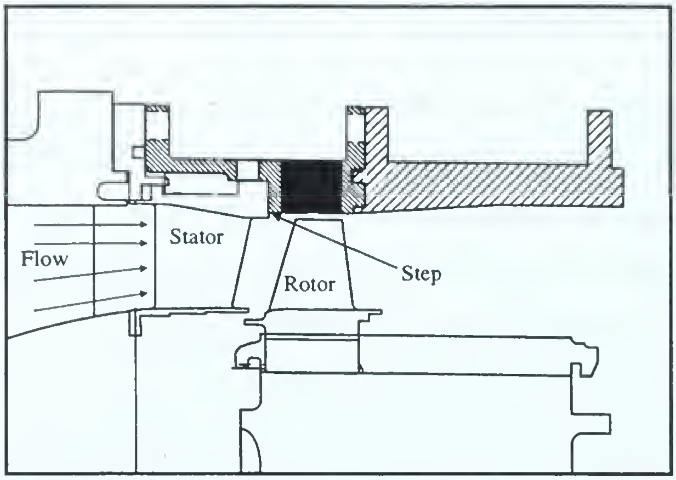


Figure 14. Step in End-Wall

B. COMBINED GRID GENERATION

The combined grid generation used TCGRID version 107 [Ref. 9: 1997]. Because the data received by Greco were for the hot-flow, and the TTR is a cold-flow turbine, he applied a thermal shrink factor of 99% to all radial and chord-wise dimensions. Five radial blade surfaces, along with modified hub and end-wall surfaces, were included in the "stator.in" and "rotor.in" files for TCGRID.

1. Stator Grid Generation

The first-stage stator grid used the same five blade surfaces as Greco's stator. The hub and end-wall were modified to account for a new position of the stator exit plane and the modeling of a step located in the rotor end-wall. Both the stator and rotor needed full hub and end-wall geometry inputs in order to match the k-planes of their grids. The stator inlet plane was at an axial location of zero. The exit plane was moved to an axial position of 1.5 inches so that the step geometry would be included in the rotor grid. The coordinate system used for a general fitted body is shown below in Figure 15.

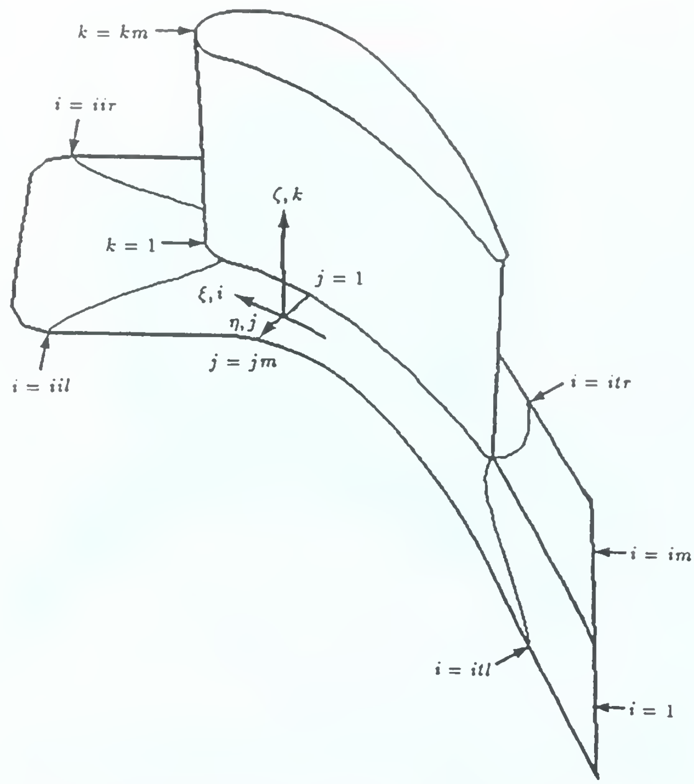


Figure 15. General Fitted Body System, from Ref. [6]

TCGRID version 107 produced grids in the PLOT-3D format and also added a dummy grid line in the j-direction so that the grids could over lap by one cell. The stator grid input dimensions were 135x31x57. TCGRID produced a grid of 135x32x57. The difference in the j-direction accounts for the added dummy grid line. The tip gap grid clustering of the rotor had to be included in the "stator.in" input file in order to match the stator's exit k-planes with the inlet k-planes of the rotor. FAST was use to view the output of TCGRID. Figures 16 and 17 show the generated stator grid.

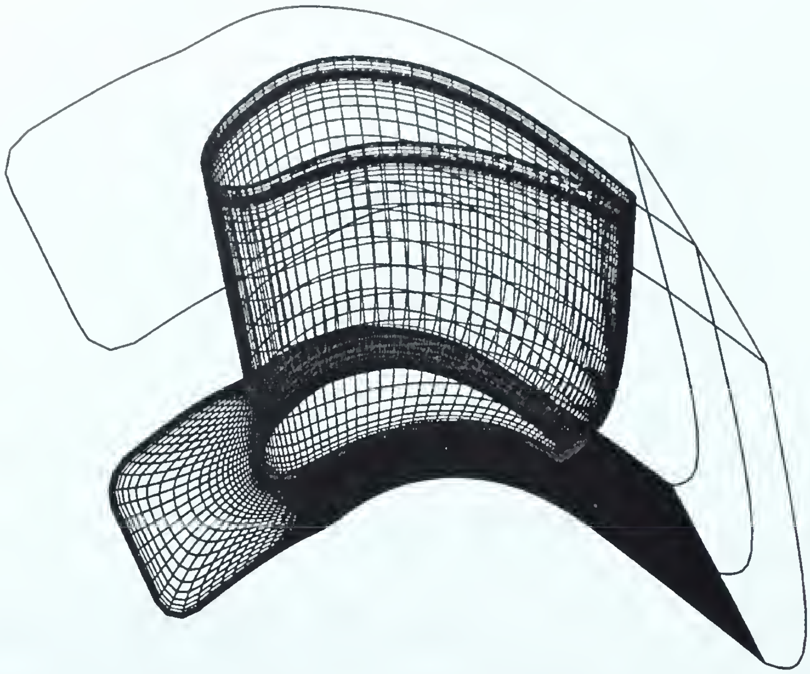


Figure 16. 3-D First Stage Stator Grid (135x32x57)

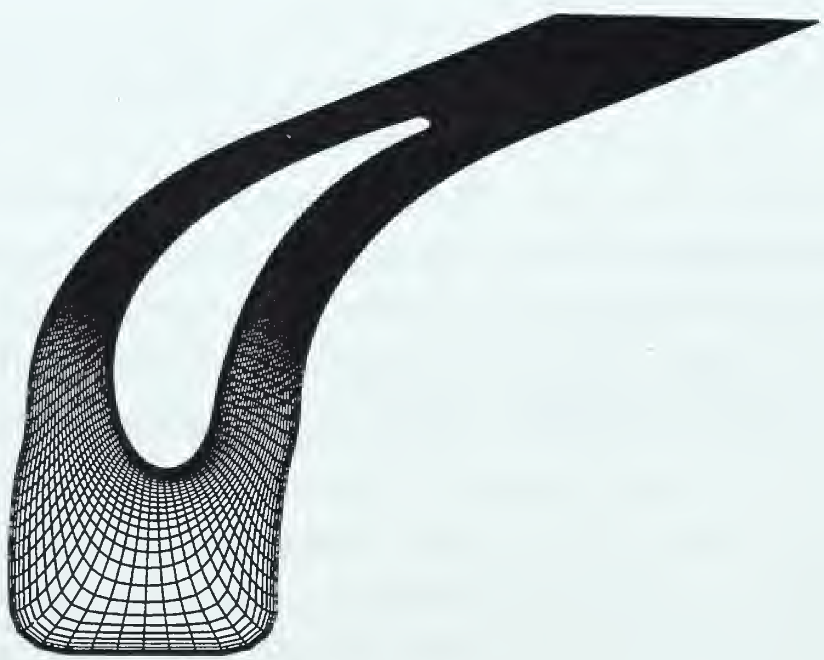


Figure 17. 2-D Stator Hub C-grid (k=1)

2. Rotor and Tip Grid Generation

The first-stage rotor grid was produced using TCGRID version 107. TCGRID produced the rotor C-grid and the tip O-grid together. A total grid of size 235x31x57 was specified. The produced grid was of size 235x32x57. Again, the difference in the j-direction accounted for the added dummy grid line. A tip gap of 0.045 inches was also specified which gave the tip O-grid a dimension of 113x13x13. The rotor accounted for k-dimension of 1-45 with the tip filling in from 45-57. The rotor inlet-plane was located at an axial position of 1.5 inches. The rotor's exit-plane was located at the probe survey location of 2.65 inches. Figures 18 through 20 show the generated rotor and tip grids.

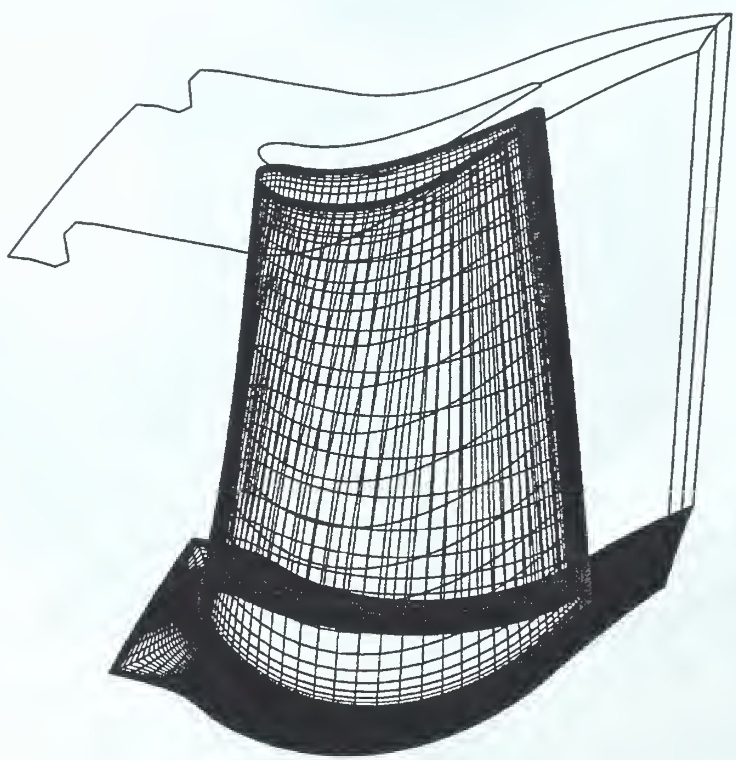


Figure 18. 3-D First-Stage Rotor Grid (235x32x57)

Figure 19. 2-D First Stage Rotor Hub (k=1)

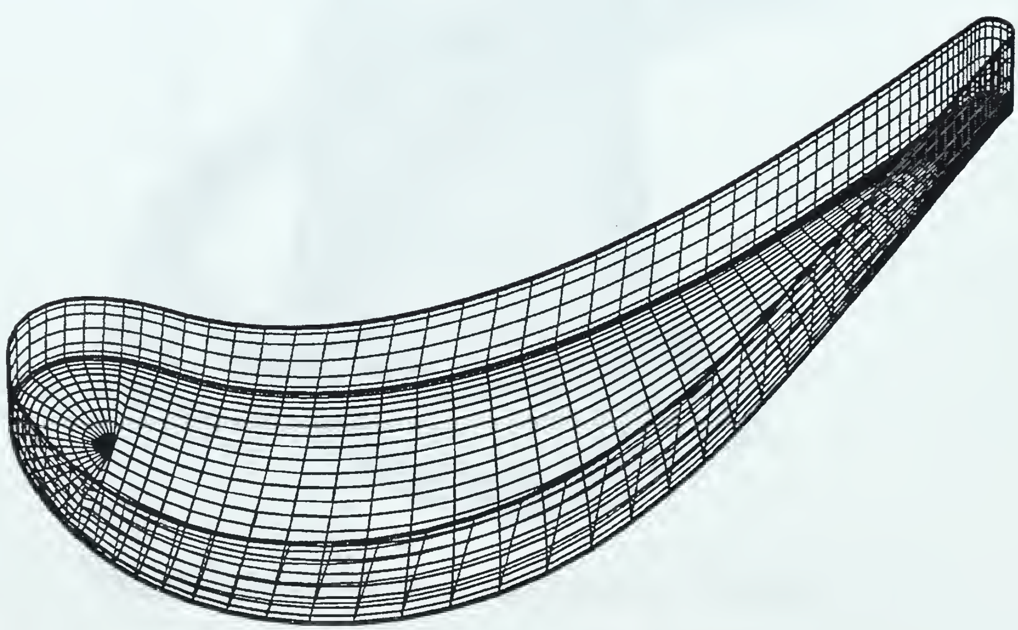


Figure 20. 3-D Tip O-grid (113x13x13)

3. Stage Grid Generation

After the stator and rotor grids were complete, several checks had to be made to ensure that the grids were compatible. The rotor grid had to overlay the aft portion of the stator grid by exactly one cell. To this end the rotor inlet was squared by setting ‘rcorn’ equal to zero (in the input file to TCGRID). The one cell overlap was met by setting ‘dsmax’ (the furthest most grid spacing away from the blade) of the rotor equal to ‘dswte’ (the spacing in the wake at the exit) of the stator. The grids were then viewed in FAST to ensure that all the k-plans matched and that there was exactly one cell overlapping. The grids were combined using a program called MULTIX to combine the grids. Figure 21 shows the first-stage stator and rotor. The combined grid output from this file was renamed to “fort.1” to be read by the flow solver SWIFT.

Figure 21 Combined First-Stage Stator and Rotor

The program MGRID was written to read the single multigrid “fort.1” file and reproduce it three times. This offered a better view of the first-stage stator and rotor and is shown in Figure 22. The one cell overlap can be

seen clearly in this figure. Appendix B contains the Fortran code for the MGRID program.

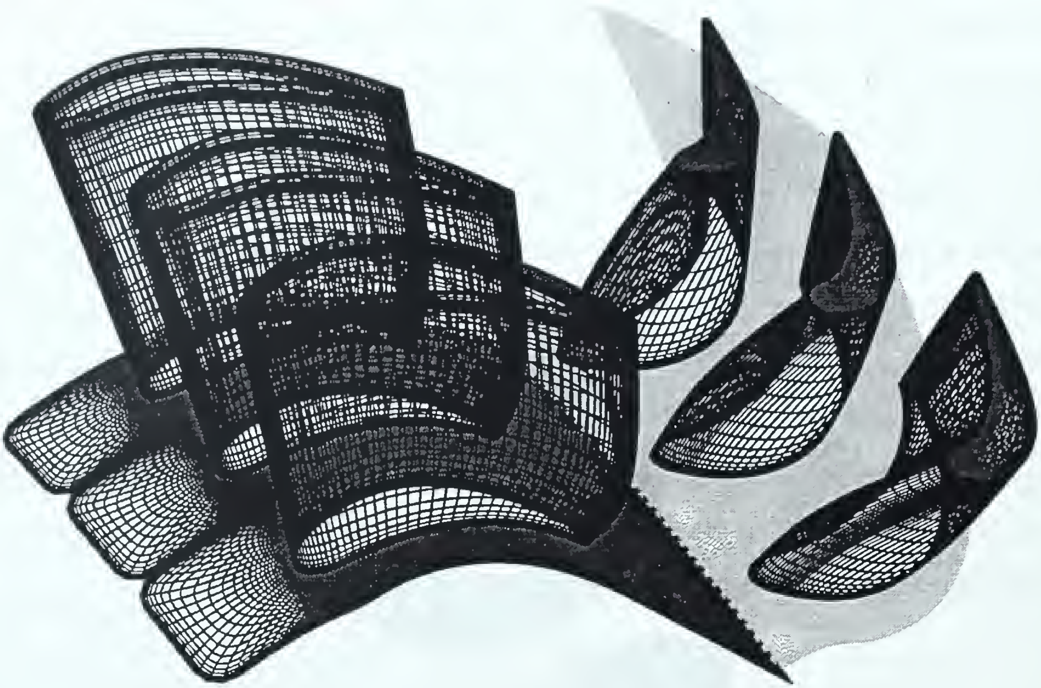


Figure 22. Combined 3-D First-Stage Stator and Rotor Grids

C. COMPUTATIONAL SCHEMES

Two flow solvers were used. RVC3D was first run on the modified stator grid describe previously. SWIFT was then tested on the modified stator. After verification by RVC3D that the code was running properly, SWIFT was used to model the flow through the stage. The Naval Postgraduate School's Cray Y-MP EL-98 supercomputer was used for all computations.

1. RVC3D

RVC3D is a rotor viscous code for three-dimensional turbomachinery flows which can only solve for flow through an isolated blade row. It solves the thin-layer Navier-Stokes equations with an explicit finite difference technique. The thin-layer assumption allowed for the streamwise viscous terms to be neglected. All cross-channel

viscous terms are retained. A Baldwin-Lowmax algebraic turbulence model was used. The equations were solved by using second-order finite-differencing spatial discretization. A multistage Runge-Kutta scheme was then applied to time march the solution. A more detailed description of RVC3D can be found in [Ref. 6: 1992].

RVC3D was used by Greco to simulate flow through the first-stage stator and rotor separately. The modified stator described above was run with identical flow conditions as specified by Greco [Ref. 4: 1995]. The output is presented in Appendix A.

2. SWIFT

The SWIFT program is a three-dimensional thin-layer Navier-Stokes program for multi-blade row turbomachinery flows. It also used finite- difference formulations with an explicit multi-stage Runge-Kutta scheme that implemented variable time-step and implicit residual smoothing. The program had the capability to run multi-blocked grids containing C-grid around blades, H-grids upstream, O-grids in the hub and tip clearance regions, and mixing-planes between blade rows. The program contained the Baldwin-Lomax and Cebeci-Smith algebraic turbulence models and the Wilcox k-omega turbulence model. A full manual for the program had not been released at the time of the present study. For details on running the program see [Ref. 9: 1997].

The program used four input files. The fort.1 file contained the grid coordinates. The "fort.2" file was used for restarts and was a copy of the solution file produced by SWIFT. The "fort.10" file contained information on grid interaction and rotation. The namelist file "muliswft.in" contained the initial conditions for each grid, as well as program flags. The program produced two files. The "fort.3" file was the solution file and was copied to "fort.2" for restarts. The "swift.out" file was an ASCII file that contained output information on the run.

The SWIFT program was initialized with calculated values from the inlet pressure and Cobra probe exit-plane survey. Momentum averaging was selected to pass information between the grids. The input lists for the runs are included in Appendix B. The run was started with a Courant number (CFL) of 2.0 and a first-order artificial viscosity of 1.0, for the first 100 iterations. The program was then restarted with a first-order artificial viscosity of 0.5 for another 100 iterations. The first-order artificial viscosity was then further dropped to 0.25 for the next 100 iterations. Zero was used for the first-order artificial viscosity for the next 100 iterations. The CFL was then change to 4.0 and the number of stages for the Runge-Kutta scheme was changed from two to four. The program was then run to 5000 iterations.

IV. RESULTS AND DISCUSSION

A. COBRA PROBE MEASUREMENTS

Four first-stage rotor exit surveys were conducted using a three-hole (Cobra) pressure probe. Reference rotational speeds ranged from a low of 4863 rpm to a high of 4869 rpm. SSME and TTR data were collected for each survey and are presented in Appendix D and E. Appendix F contains the VEL_PRFL.VI data output as well as graphs of Mach number and swirl angle vs. radial position for each individual survey. Figures 23 and 24 show the combined graphs of Mach number and swirl angle vs. radial position for the four surveys.

Both the Mach number and swirl angle graphs showed good consistency in the measured results and did not show any dependency on circumferential location. The complex structure exhibited by both graphs suggested the existence of secondary flow effects. The most plausible explanation of these structures are tip-leakage vortices generated by the rotor tip gap. This gap was measured, while rotating, to be .045 inches after resurfacing of the inner wall. This differs from the measured value of .020 inches, measured while rotating, reported in Southward [Ref. 5: 1998]. The inner casing wall was resurfaced due to damage caused by bearing failure.

The distribution of both plots were similar to that of Southward's [Ref. 5: 1998] measurements. A more pronounced "s" shape was observed in the plot of Mach number vs. radial position compared to Southward's plot. Minimum Mach number was observed at 89% (vs. 80%) span while maximum Mach number occurred at 65% (vs. 20%) span. This can be attributed to a larger vortex being generated by the larger tip clearance gap. The shape of the swirl angle plots were almost identical, however

the angles measured were approximately -5° lower throughout when compared to Southward.

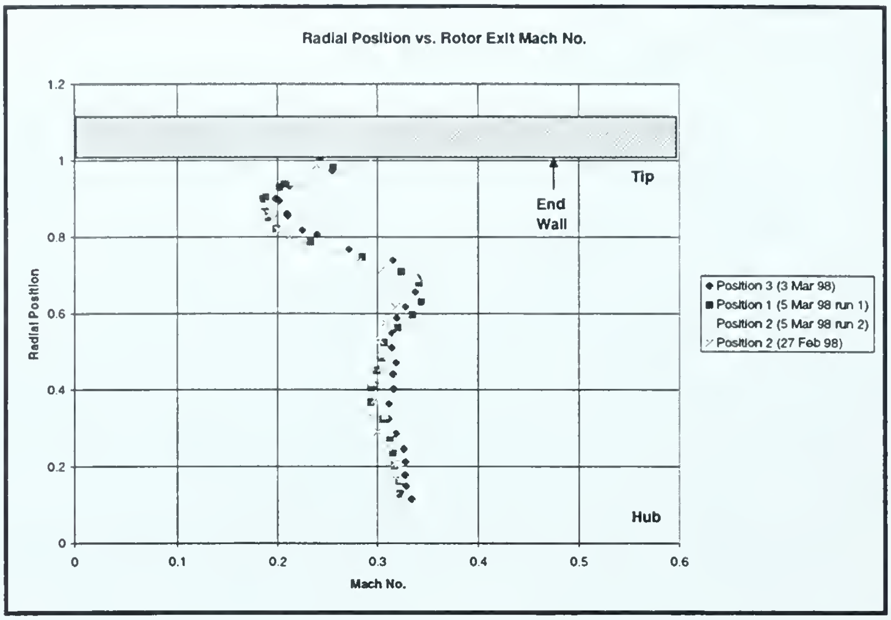


Figure 23. Combined Cobra Probe Measurements of Mach Number

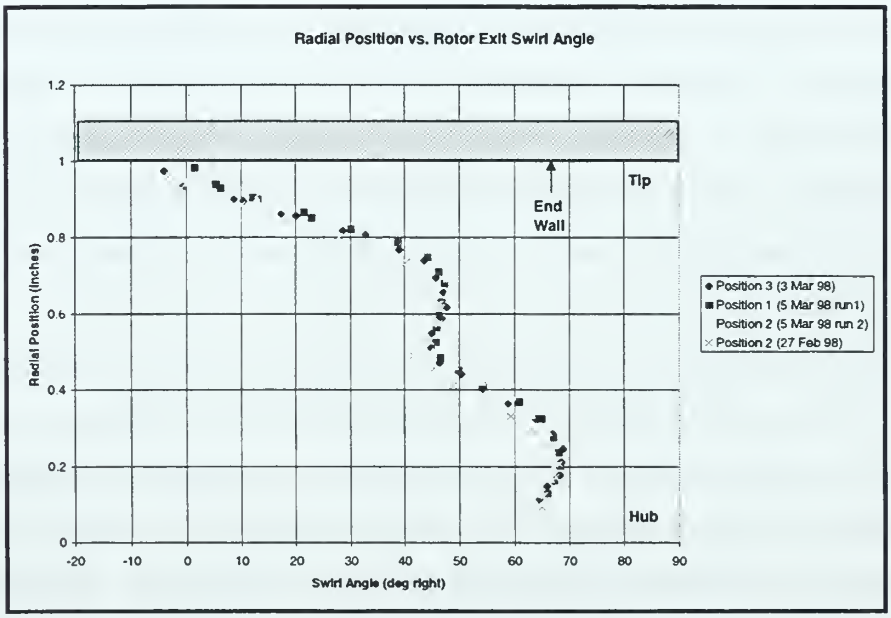


Figure 24. Combined Cobra Probe Measurements of Swirl Angle

B. LASER DOPPLER VELOCIMETRY MEASUREMENTS

The LDV surveys were conducted at two axial locations in the rotor tip-gap region. The majority of the surveys concentrated on the forward hole, located at $-0.16c_t$. The other survey position was located at $0.35c_t$. The reference rotational speed ranged from 4781 rpm to 4862 rpm. Data were taken at three depths per axial position. The three depths, from the end-wall, were located at 0.019 inches (98% span), 0.069 inches (93% span) and 0.119 inches (88% span). Refer to Southward [Ref. 5: 1998] for a detailed description of the setup and operation of the LDV.

Repeatability of the data sets was not good. The tangential flow velocity and angles varied widely. Only the forward position's innermost depth had some repeatable data. This set was the axial component of flow velocity. Three of the four measurements varied only 4%. All other data sets followed no pattern. Figures 25 through 36 show the results of the plotted data. Appendix G contains the window-averaged data with parameters for each survey. With the exception of one forward inner LDV survey, the tangential laser beam was shifted by –10MHz. For all runs the axial beam was not shifted. Both processor filter settings were set to 5-30MHz for all runs.

Both frequency-shifters were found to be faulty and were sent out to be repaired. Upon return and testing of the repaired frequency-shifters, the PHASE optical setup was found to be in error. An input of –10 had been used as the setup for the tangential frequency shifting. This number should have been a positive 10. Before any other measurements could be preformed, the axial compressor drive motor developed a vibration and was sent out for repair. This precluded any further measurements on the TTR.

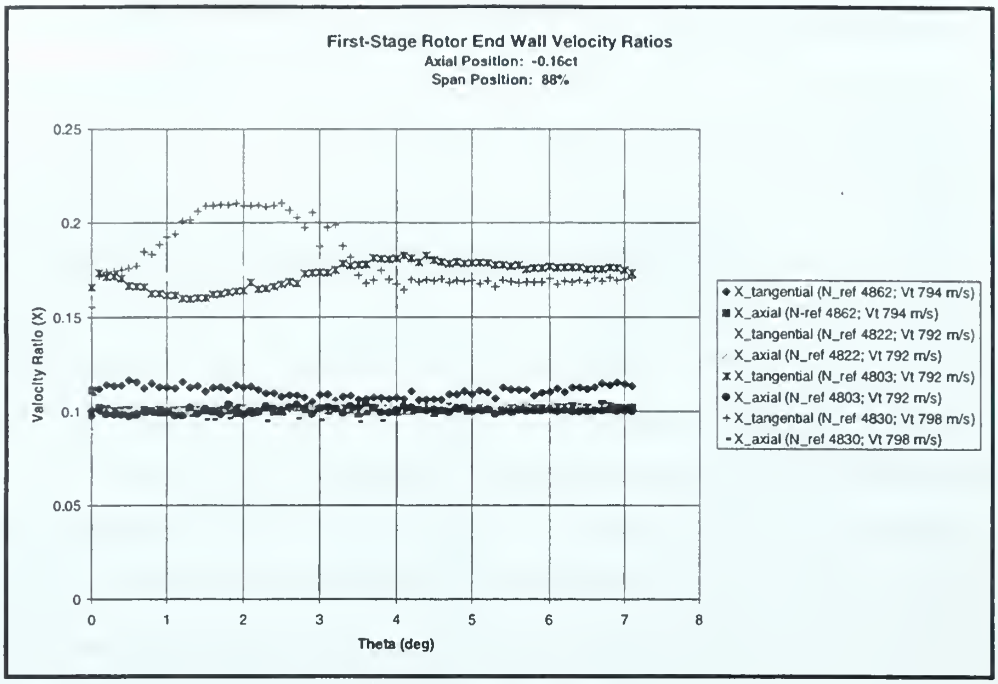


Figure 25. LDV Velocity Ratios for $-0.16c_t$ and 88% Span

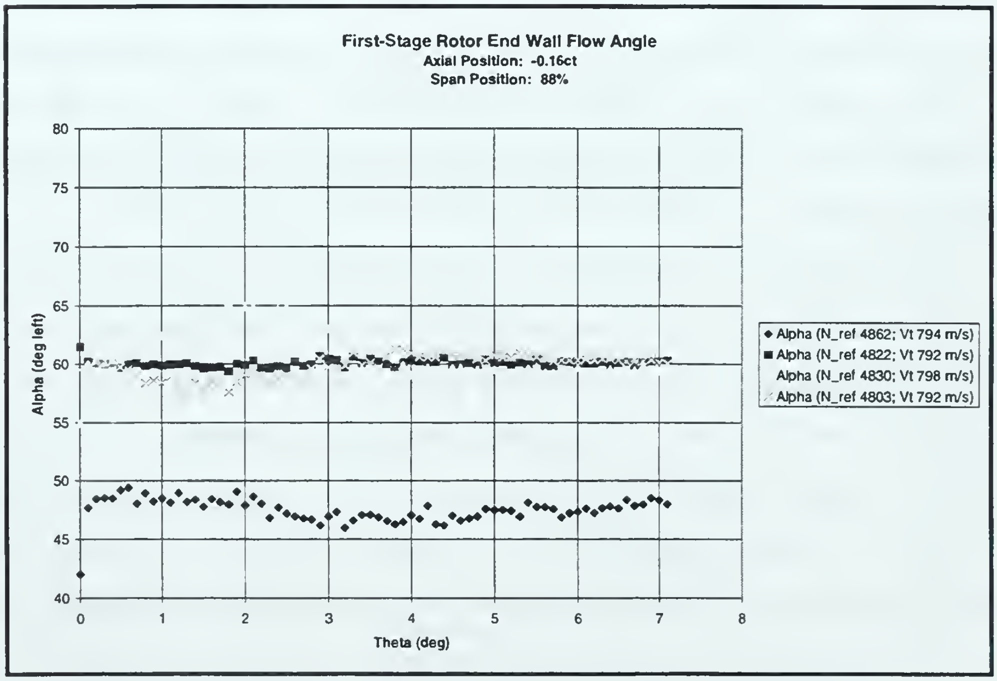


Figure 26. LDV Absolute Flow Angle for $-0.16c_t$ and 88% Span

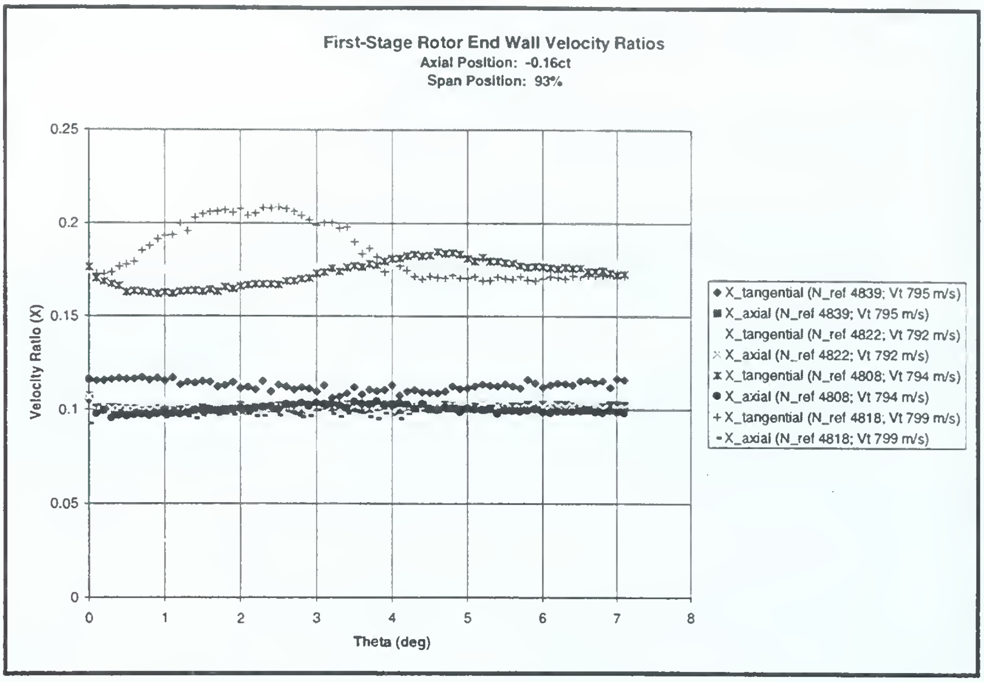


Figure 27. LDV Velocity Ratios for $-0.16c_t$ and 93% Span

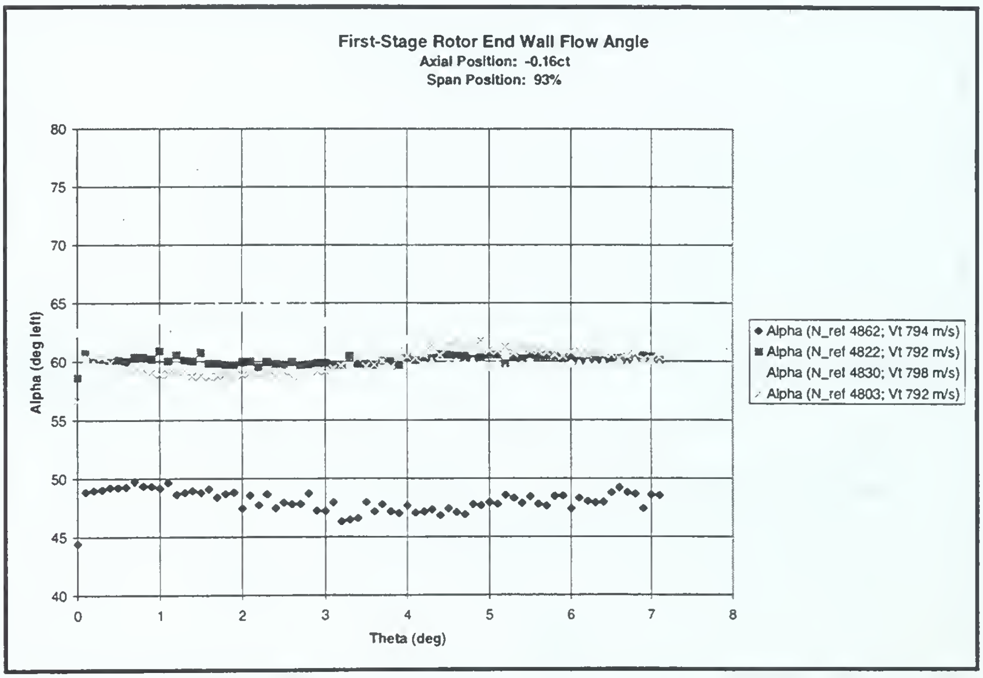


Figure 28. LDV Absolute Flow Angle for $-0.16c_t$ and 93% Span

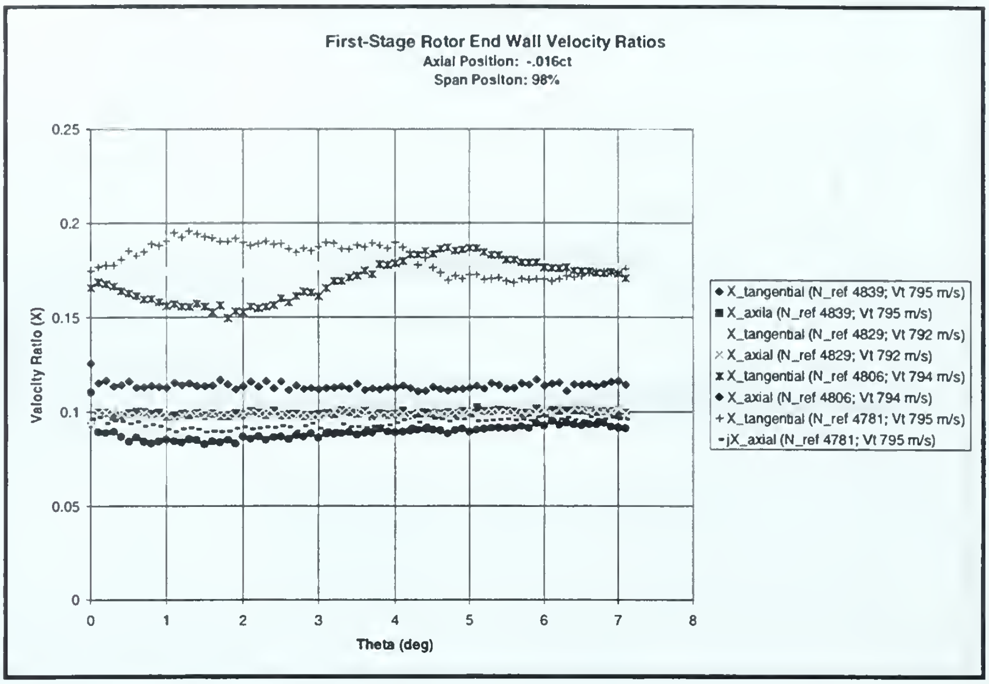


Figure 29. LDV Velocity Ratios for –0.16c$_t$ and 98% Span

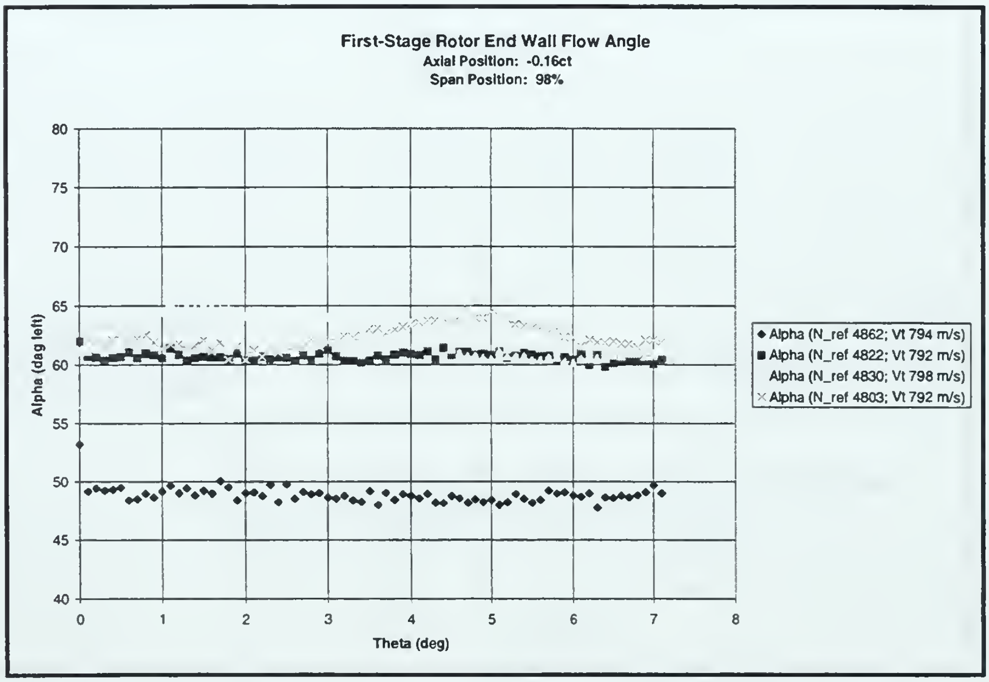


Figure 30. LDV Absolute Flow Angle for –0.16c$_t$ and 98% Span

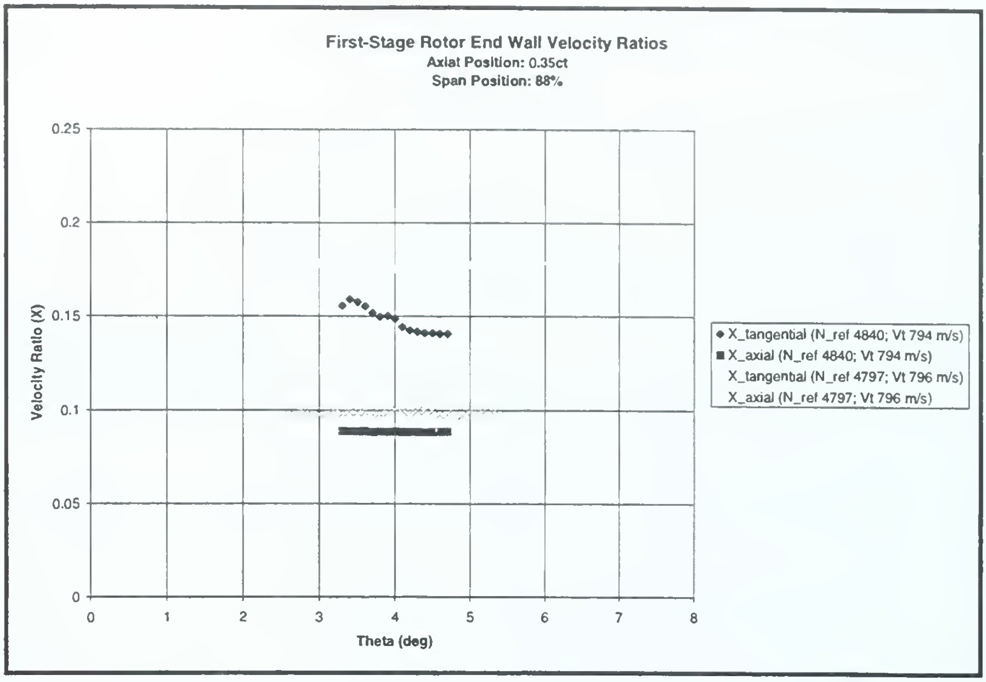


Figure 31. LDV Velocity Ratios for $0.35c_t$ and 88% Span

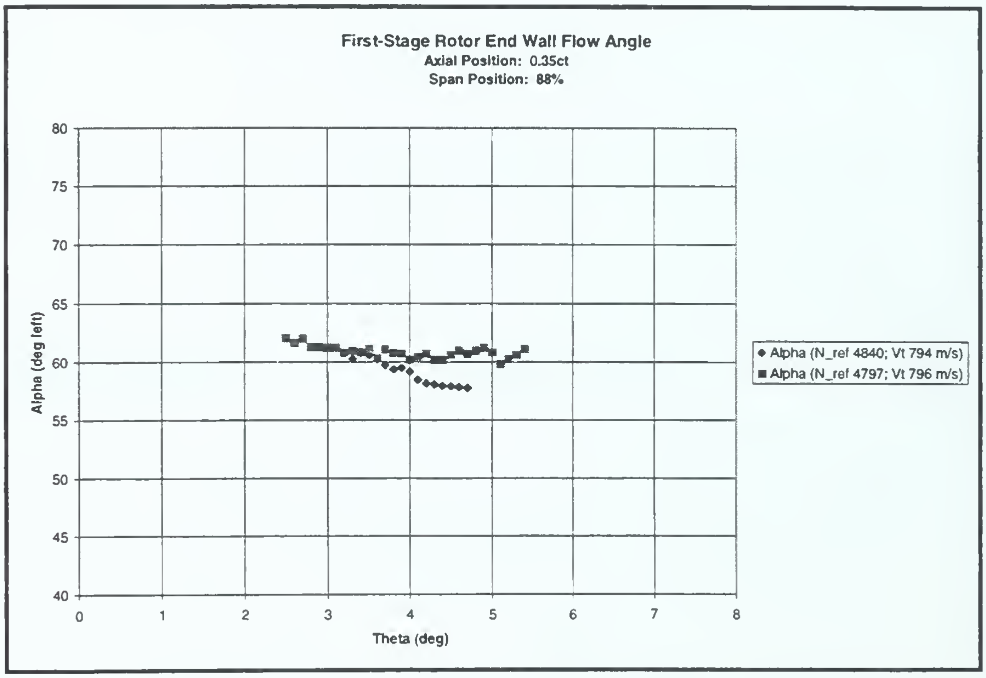


Figure 32. LDV Absolute Flow Angle for $0.35c_t$ and 88% Span

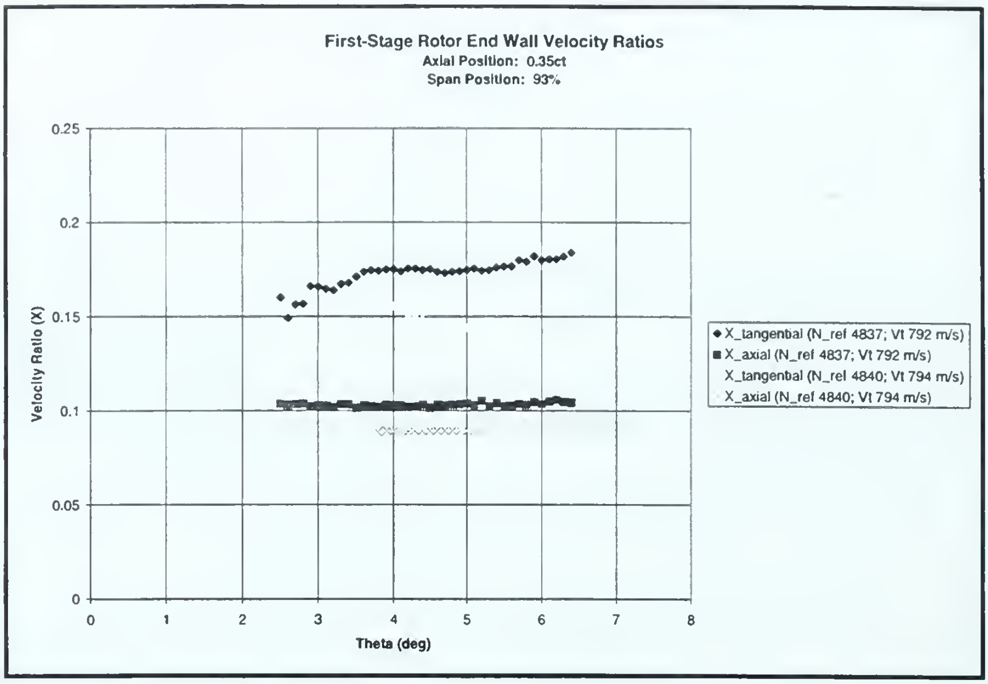


Figure 33. LDV Velocity Ratios for $0.35c_t$ and 93% Span

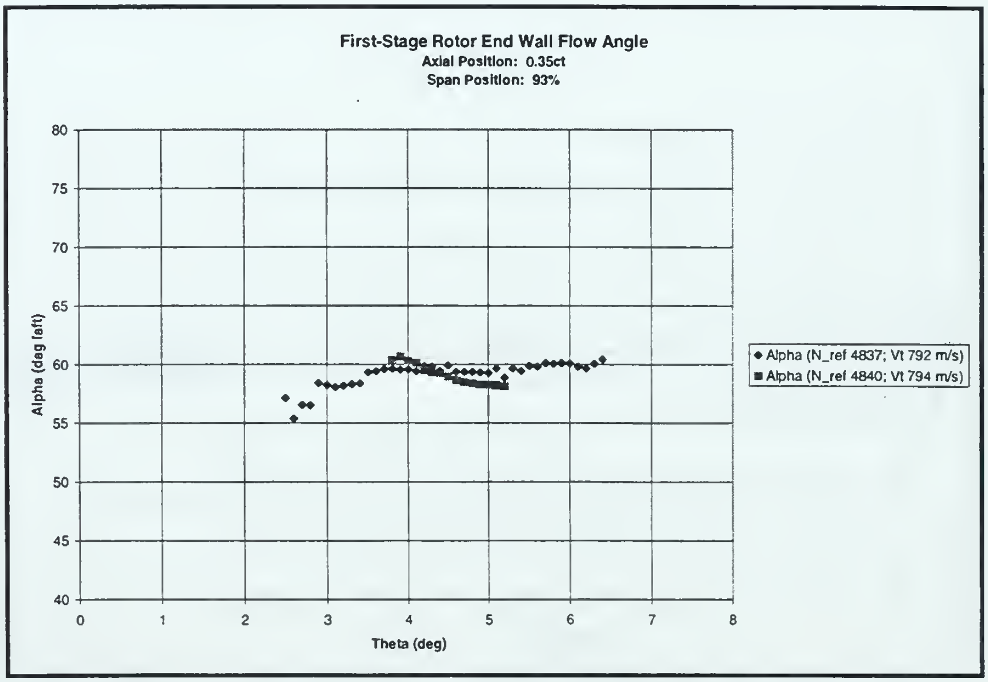


Figure 34. LDV Absolute Flow Angle for $0.35c_t$ and 93% Span

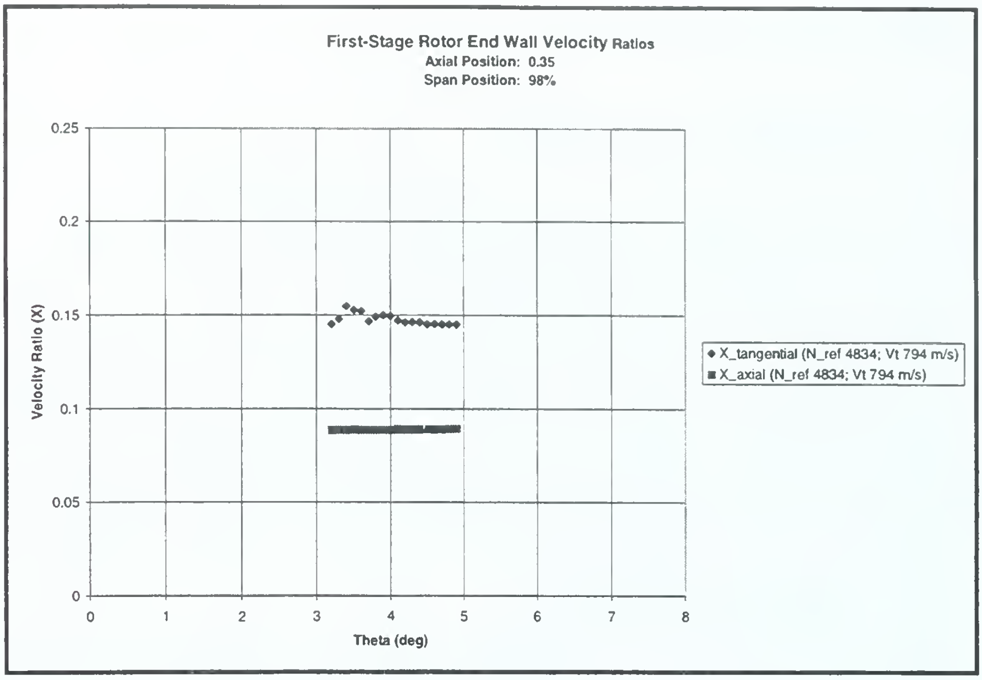


Figure 35. LDV Velocity Ratios for $0.35c_t$ and 98% Span

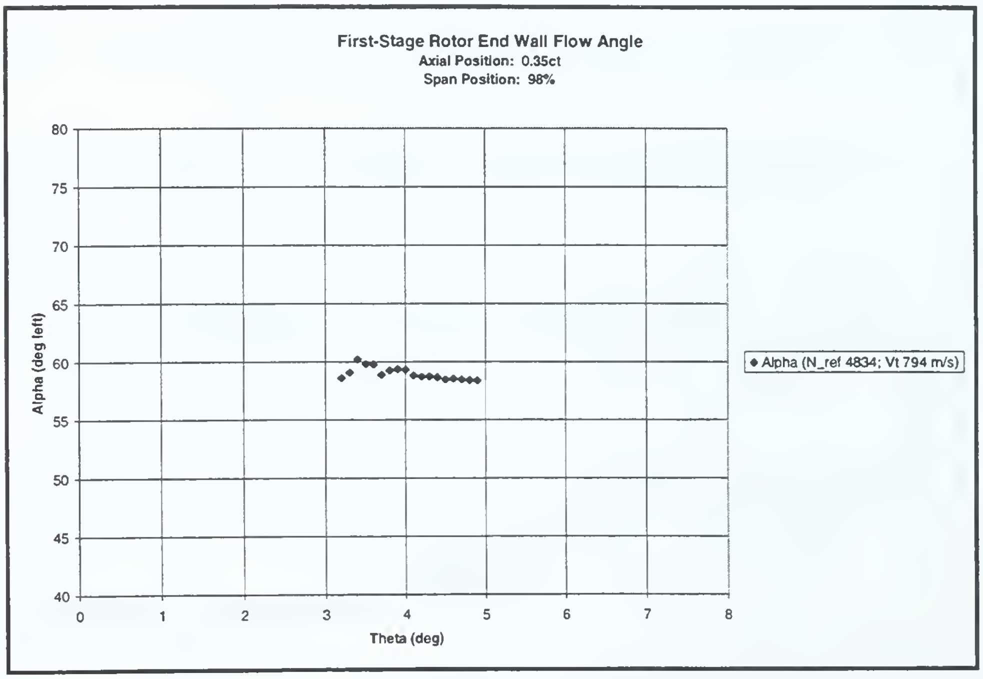


Figure 36. LDV Absolute Flow Angle for $0.35c_t$ and 98% Span

C. NUMERICAL RESULTS

1. Modified Stator Model

Once the grid was developed to model the step in the outer casing, both RVC3D and SWIFT were run to 5000 iterations and the data compared. The residuals for the RVC3D had not reached convergence but the SWIFT model converged after 2500 iterations. The residuals for the RVC3D run dropped over three orders of magnitude while the SWIFT had stabilized at 2.8 orders of magnitude. Plots of the residuals and coefficient of pressure at mid-span can be found in Appendix A.

2. Combined Model

The combined first-stage grid was run out to 5000 iterations. The residuals reduced by two orders of magnitude before converging at 3500 iterations (Figure 37). The exit plane of the rotor showed very little grid dependency as can be seen in Figures 40 through 46.

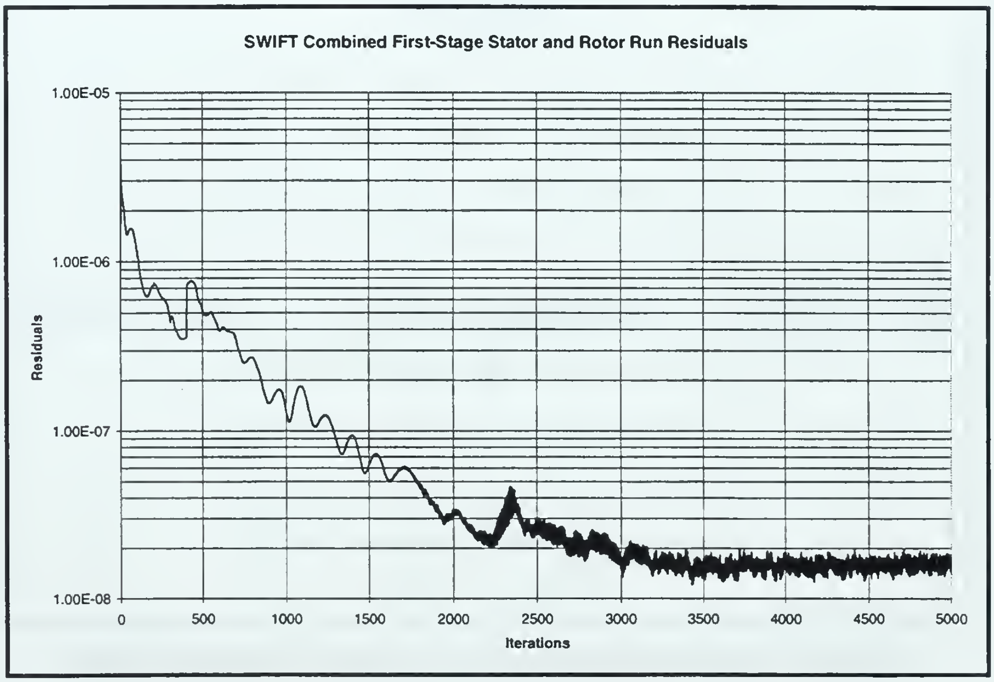


Figure 37. Residual of Combined First-Stage Stator and Rotor

The SWIFT program produced a momentum-averaged output of the rotor exit plane. These data are included in Appendix H and were used to plot the Mach number and swirl angle vs. radial position (Figures 38 and 39).

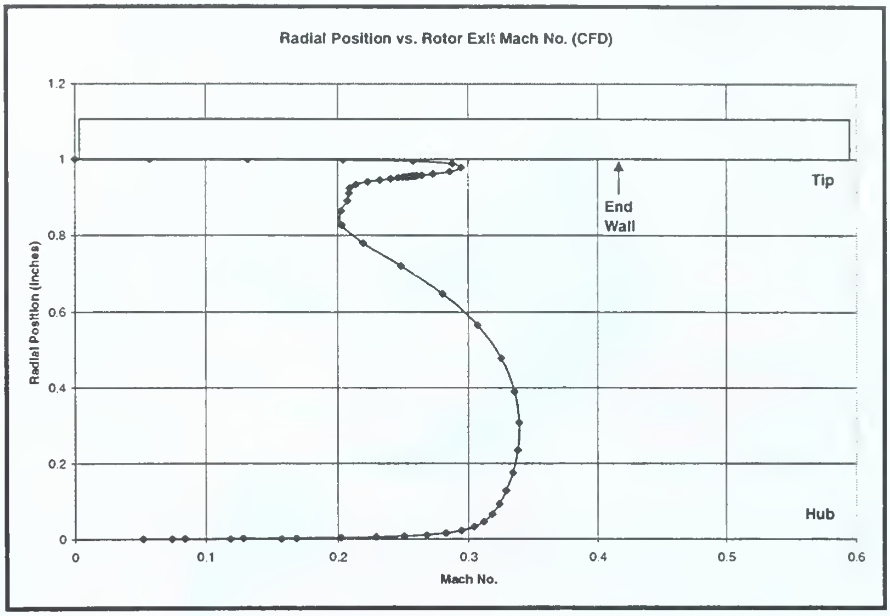


Figure 38. CFD Rotor Exit Plane Averaged Mach No.

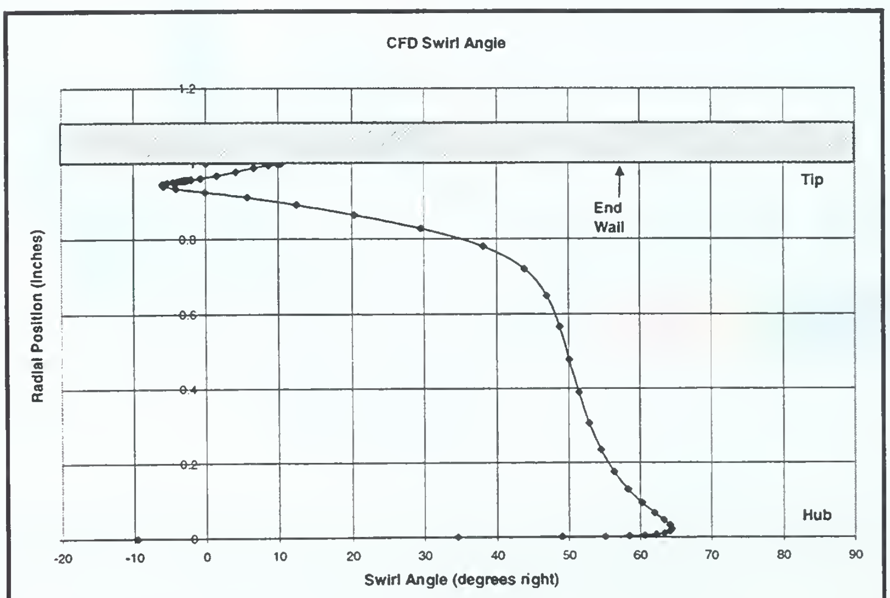


Figure 39. CFD Rotor Exit Plane Averaged Swirl Angle

Figure 40 is a composite plot of blade surface pressure distributions for the stage. The midspan Mach number distribution is plotted between the blades and the exit plane Mach number distribution is shown as contour lines. The high-pressure stagnation region is evident on the leading edge of the stator blade. Figure 41 shows the stage midspan Mach number distribution, which shows increasing magnitudes as the flow accelerates through the turbine. In these, figures the contour lines show a distinctly circular pattern of Mach number gradients downstream of the rotor tip. This is indicative of a vortex being shed by the rotor. In Figure 42, tip leakage can be observed between the rotor tip and the end-wall. The flow in the step-region decreases in Mach number as it passes the step. This result would be expected. In Figures 43 through 45, the static pressure is shown on the rotor wall. In these figures, it can be seen that the pressure on the rotor tip drops as the flow speeds up and leaks between the tip and the end-wall. The tip leakage would support the generation of a trailing vortex.

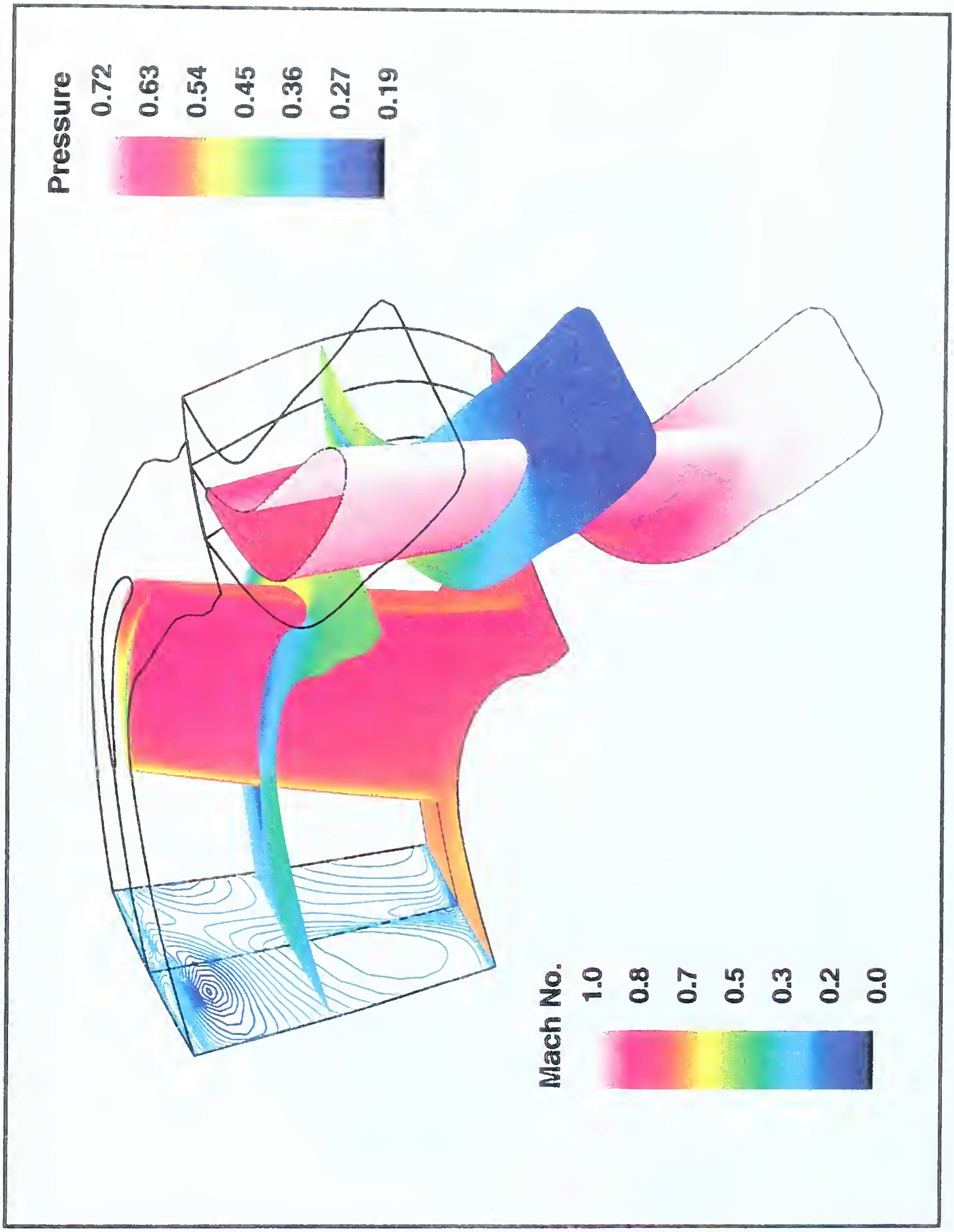


Figure 40. Combined First-Stage (Static Pressure on Walls, Mach Number at Mid Section and Mach Contours at Exit Plane)

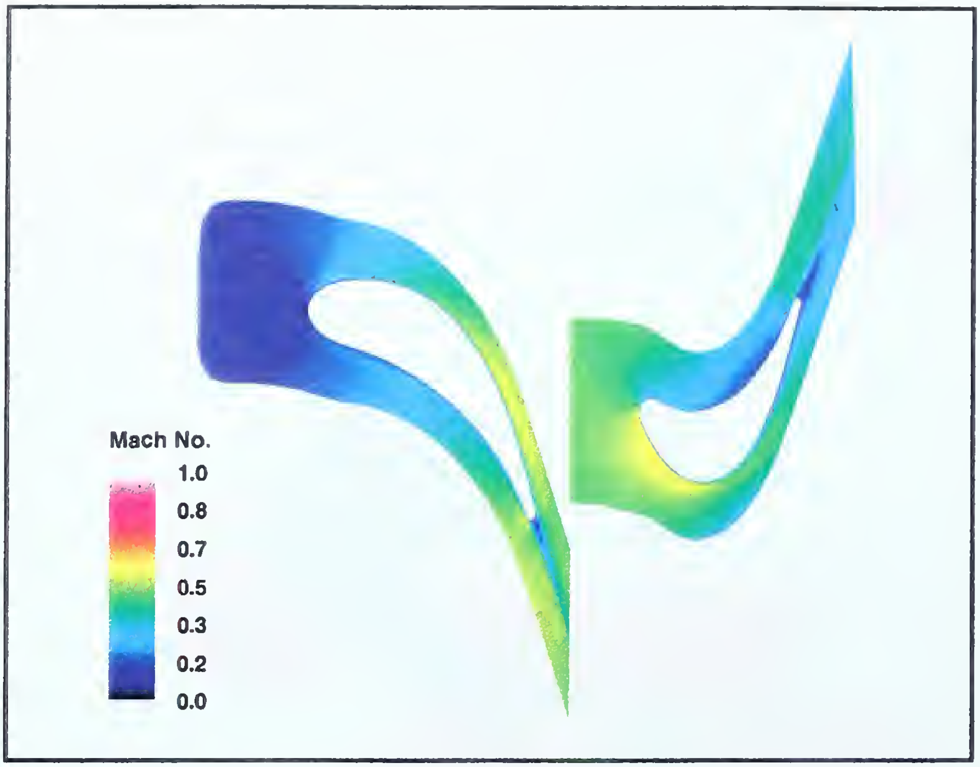


Figure 41. Combined First-Stage (Mach Number at Mid Section, k=24)

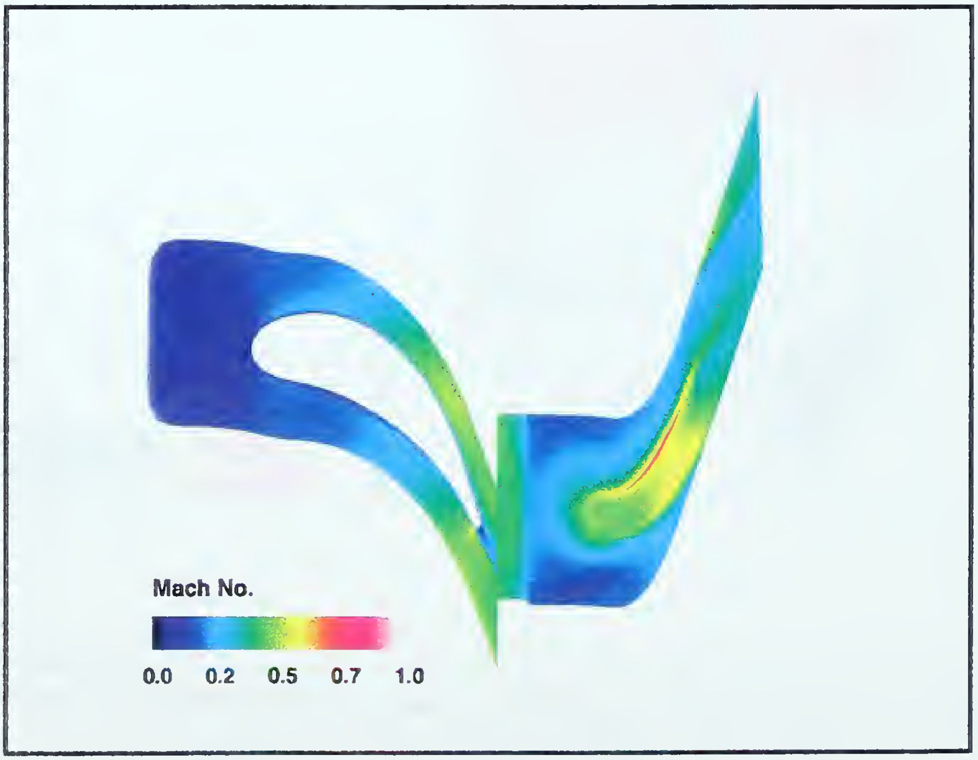


Figure 42. Combined First-Stage (Mach Number at Mid Section, k=50)

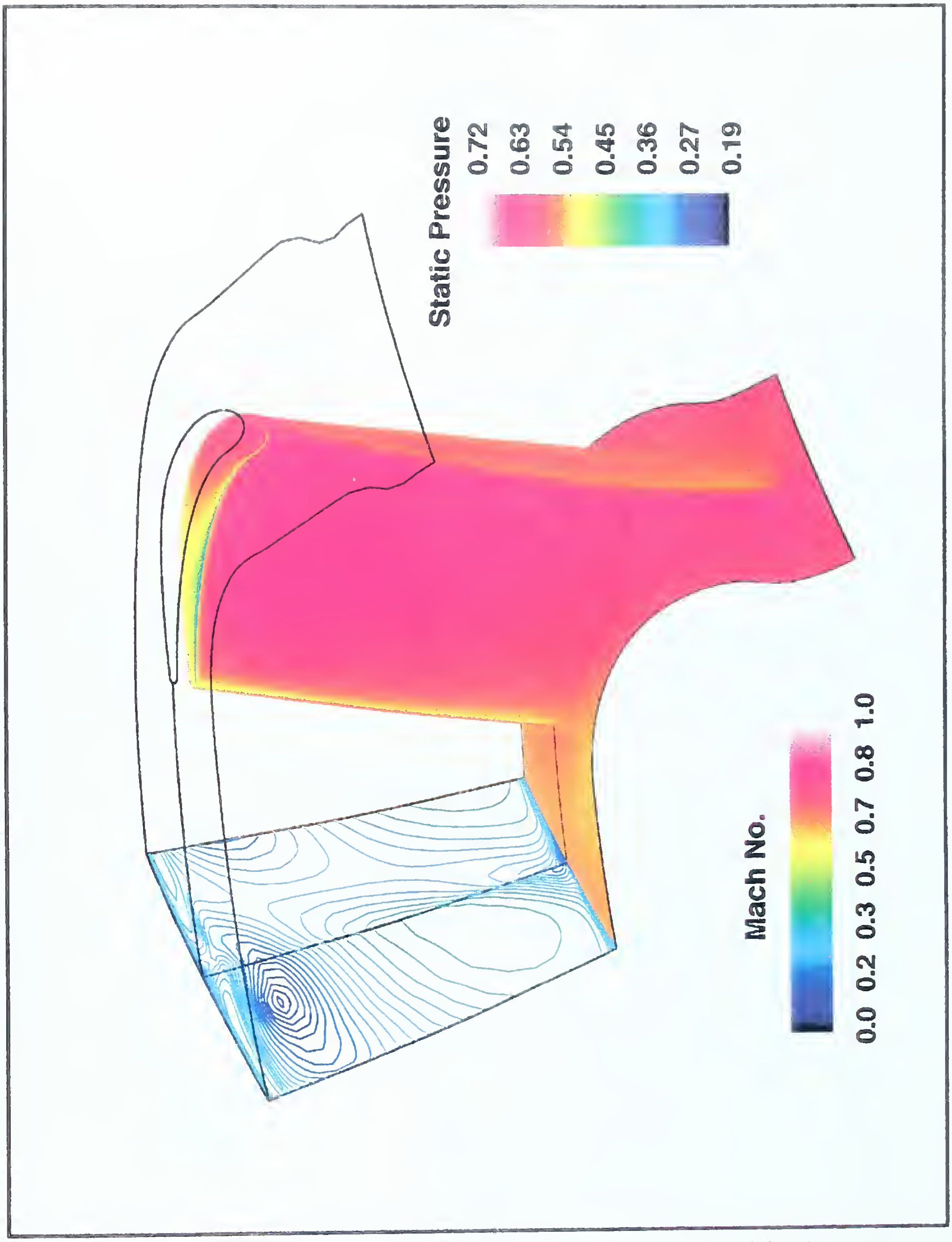


Figure 43. Combined First-Stage (Mach Contours at Exit Plane)

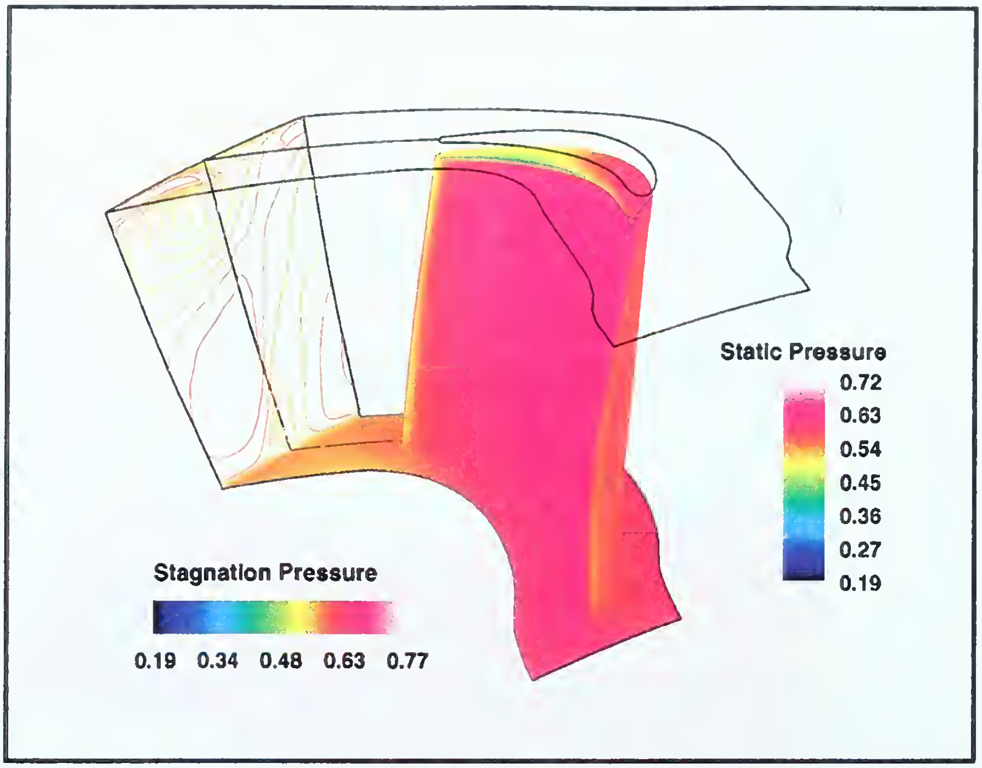


Figure 44. Combined First-Stage (Stagnation Pressure Contours at Exit Plane)

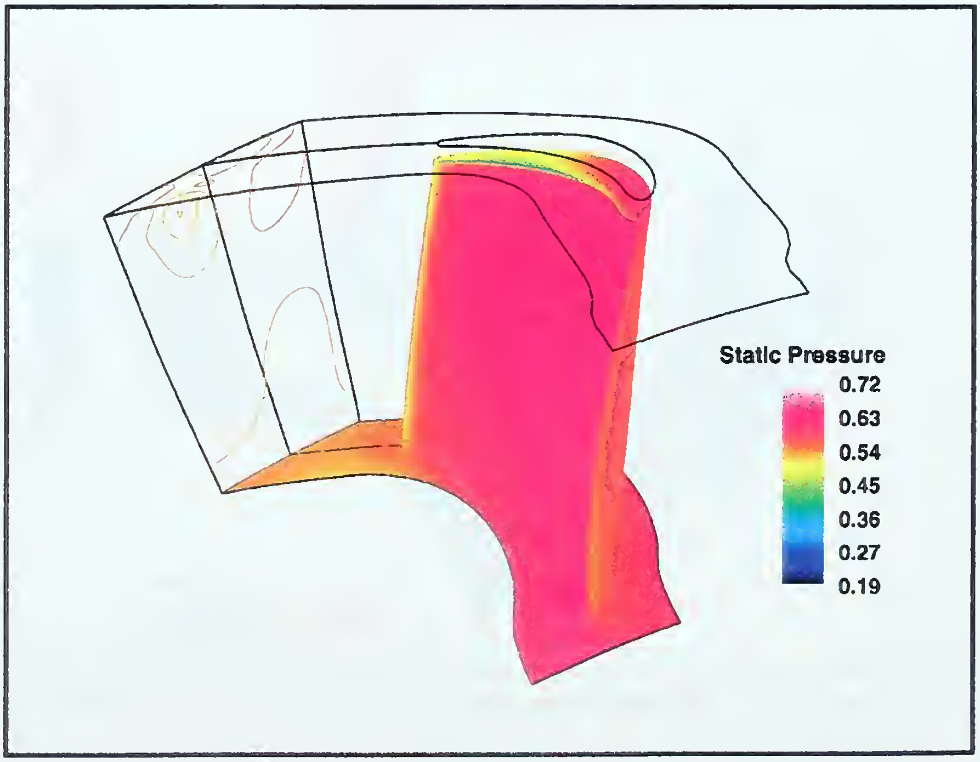


Figure 45. Combined First-Stage (Static Pressure Contours at Exit Plane)

D. EXPERIMENTAL VS. NUMERICAL COMPARISON

Momentum-averaged computational results for the rotor exit plane were plotted for comparison with the Cobra probe measurements (Figures 46 and 47). The predicted Mach number distribution in Figure 46 showed good agreement with the measured data, particularly in the tip region, where the radial location of the tip leakage vortex was correctly predicted. The computational results did not show the distinct "s" shape in the mid-section that the Cobra probe data exhibited, but the average magnitudes were fairly close. The grid line spacing in the mid-section of the rotor was large and this could be a possible cause for the departure.

Figure 47 showed the swirl angle results. In the end-wall region, the plots overlapped. The numerical model did not follow the Cobra probe measurements from 60% span down to the hub. This departure can be attributed to poor modeling of the hub region. The step inward of the rotor hub, in the test turbine, was not modeled. This was the greatest source of disagreement between the experimental and computational results in the hub region.

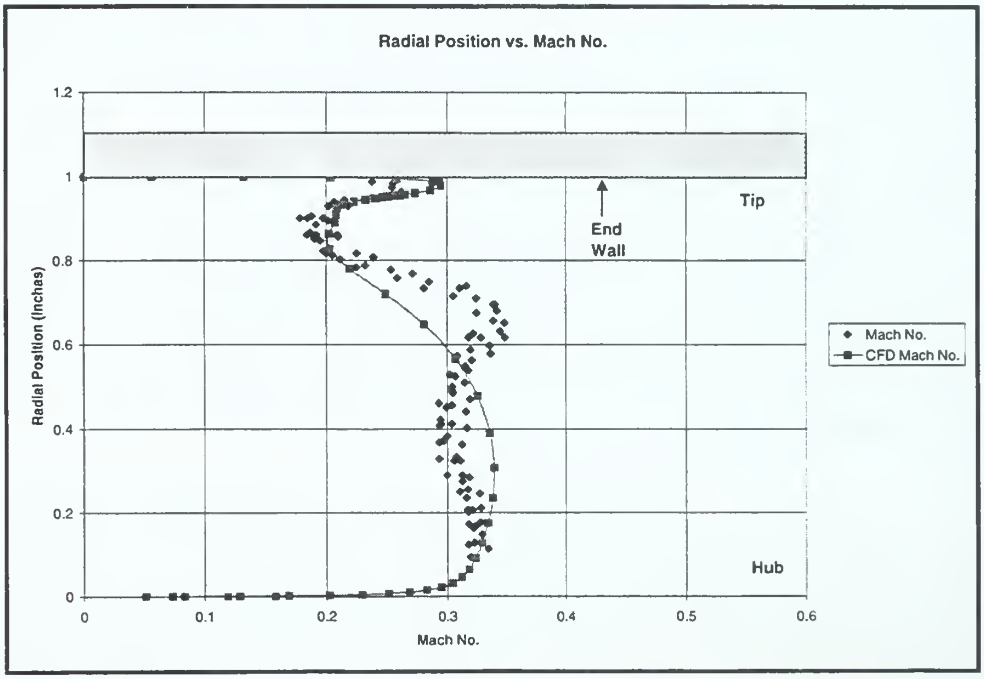


Figure 46. CFD and Combined Cobra Probe Measurements of Mach No.

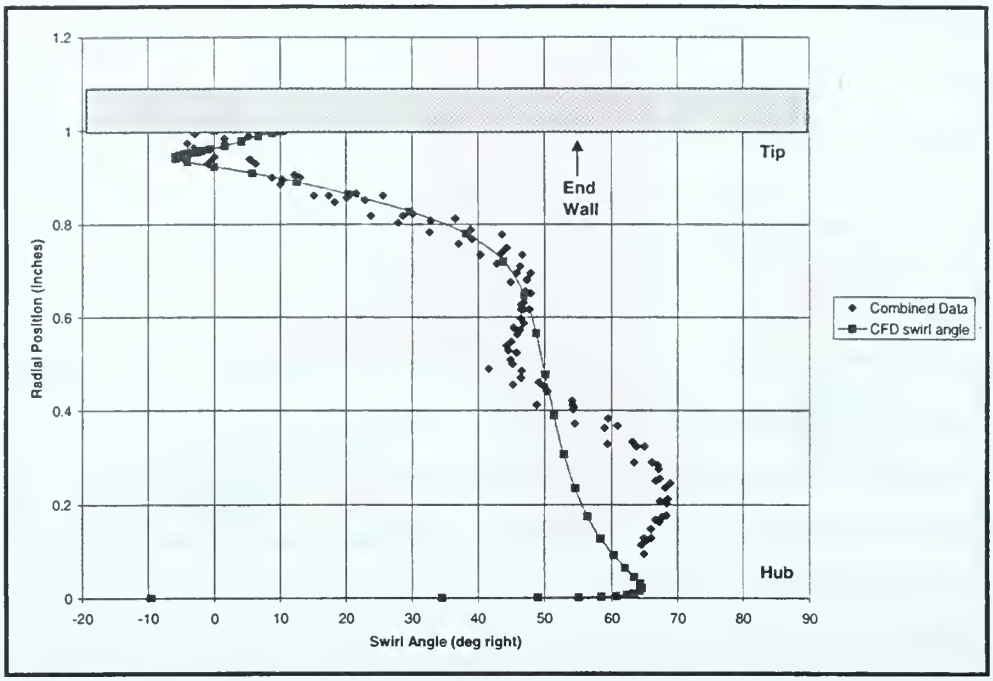


Figure 47. CFD and Combined Cobra Probe Measurements of Swirl Angle

V. CONCLUSIONS AND RECOMMENDATIONS

A. COBRA PROBE MEASUREMENTS

The Cobra probe measurements were successfully completed. The results showed that the inlet struts (of which there were 16) had little effect on the downstream rotor exit flow. The replacement of the soft plastic tubing on the probe increased the reliability and repeatability of the measurements. Redesign of the Cobra probe mount is needed in order to protect the probe tip while being installed and removed. A method for a more precise axial alignment of the probe is needed, to eliminate the inaccuracy introduced by only visually aligning the probe tip with the axial direction of the turbine.

B. LDV MEASUREMENTS

The LDV measurements were considered to be unsuccessful. The non-repeatability in the LDV measurements can be attributed to the noise that had developed in the frequency shifters. Replacement of these frequency shifters should eliminate this problem. The modification to the seeding wand did increase data rate acquisition between blade passages. The correction of the PHASE software optical setup should also lead to better correlation between frequency-shifted data and non-shifted data. Backscatter is still a problem. A field stop should be installed as Southward recommended [Ref. 5: 1998]. The refurbishment of the axial compressor drive motor should help stabilize the TTR rotational speed, leading to smaller variations in reference rpm between successive runs.

C. COMPUTATIONAL FLUID DYNAMICS

The initial computational fluid dynamics modeling results were successful. Good agreement between the Cobra probe measurements and the computational results was obtained. Insight into the flow around the

rotor tip was also gained. The stator and rotor grids both need refinement. Addition of more span-wise points (increase the dimension of k) is needed for both grids. The stator grid needs greater clustering of points in the axial direction, aft of the stator's trailing edge. The rotor grid needs an increase in the density of points in the j dimension in order to better model the step in the end-wall casing. Investigation of the other turbulence models available in the SWIFT program could lead to better agreement between the experimental and computational results.

APPENDIX A. MODIFIED STATOR

A. TCGRID INPUT FILE FOR MODIFIED STATOR

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       dstip=0.0001 dswte=0.005 dswex=0.03 dsthr=1.0 dsmin=0.001
       dsmax=0.02 rcorn=.098 &end
 &nam3 iterm=150 idbg=0 0 0 0 0 0 0 0 aabb=1.0 &end
 &nam4 zbc=0.0000 0.0000 2.2500 0.0000 0.0000 2.2500
       rbc=4.0788 4.0788 4.0788 5.1480 5.1480 5.1480 &end
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 58  58
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   -0.5000787     -0.4134042     -0.3267396     -0.2400750     -0.1534005
   -6.6735901e-02  1.9928699e-02  0.1066032      0.1932678      0.2799324
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    1.287020       1.310730       1.334510       1.358349       1.382228
    1.406137       1.430055       1.578555       1.617592       1.620448
    1.622869       1.624487       1.625055       1.625623       1.627241
    1.629662       1.632517       1.750000

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    3.902798       3.921746       3.939557       3.956248       3.971821
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    4.042595       4.050704       4.057773       4.063811       4.067732
    4.068662       4.069979       4.070999       4.072147       4.073206
    4.074018       4.074761       4.075573       4.076187       4.076830
    4.077384       4.077850       4.078216       4.078533       4.078711
    4.078780       4.078800       4.078800       4.078800       4.078800
    4.078800       4.078800       4.078800       4.078800       4.078800
    4.078800       4.078800       4.078800       4.078800       4.078800
    4.078800       4.078800       4.078800       4.078800       4.078880
    4.078800       4.078800       4.078800

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    1.622869       1.624487       1.625055       1.625623       1.627241
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   5.148000        5.148000        5.148000        5.148000        5.148000
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   5.137615        5.133873        5.129556        5.124685        5.119240
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   5.079502        5.053010        5.047565        5.042694        5.038377
   5.034636        5.031467        5.028873        5.026854        5.025408
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   5.026436        5.028857        5.031713        5.094268        5.096689
   5.098307        5.098875        5.098875

6   105   52
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   1.212453        1.204236        1.196019        1.187802        1.179585
   1.159042        1.138500        1.117958        1.097415        1.076872
   1.056330        1.035787        1.015245        0.994703        0.974160
   0.953618        0.933075        0.912533        0.891990        0.871448
   0.850905        0.830362        0.809820        0.789277        0.768735
   0.748192        0.727650        0.707107        0.686565        0.666022
   0.645480        0.624937        0.604395        0.583853        0.563310
   0.542768        0.522225        0.514008        0.505791        0.497574
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   0.448272        0.440055        0.448272        0.456489        0.464706
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   0.514008        0.522225        0.542768        0.563310        0.583853
   0.604395        0.624937        0.645480        0.666022        0.686565
   0.707107        0.727650        0.748192        0.768735        0.789277
   0.809820        0.830362        0.850905        0.871448        0.891990
   0.912533        0.933075        0.953618        0.974160        0.994703
   1.015245        1.035787        1.056330        1.076872        1.097415
   1.117958        1.138500        1.159042        1.179585        1.187802
   1.196019        1.204236        1.212453        1.220670        1.228887
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0.010300	0.002480	-0.006300	-0.016110	-0.020330
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-0.048880	-0.054130	-0.059510	-0.065580	-0.068700

5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250
5.024250	5.024250	5.024250	5.024250	5.024250

1.441965	1.431837	1.421719	1.411601	1.401484
1.391366	1.381238	1.371120	1.361003	1.350885
1.325580	1.300276	1.274981	1.249677	1.224373
1.199078	1.173774	1.148479	1.123175	1.097870
1.072576	1.047271	1.021967	0.996673	0.971368
0.946074	0.920769	0.895465	0.870170	0.844866
0.819562	0.794267	0.768963	0.743658	0.718364
0.693059	0.667765	0.642461	0.617156	0.591862
0.566557	0.541253	0.531135	0.521017	0.510899
0.500782	0.490654	0.480536	0.470418	0.460301
0.450173	0.440055	0.450173	0.460301	0.470418
0.480536	0.490654	0.500782	0.510899	0.521017
0.531135	0.541253	0.566557	0.591862	0.617156
0.642461	0.667765	0.693059	0.718364	0.743658
0.768963	0.794267	0.819562	0.844866	0.870170
0.895465	0.920769	0.946074	0.971368	0.996673
1.021967	1.047271	1.072576	1.097870	1.123175
1.148479	1.173774	1.199078	1.224373	1.249677

1.274981	1.300276	1.325580	1.350885	1.361003
1.371120	1.381238	1.391366	1.401484	1.411601
1.421719	1.431837	1.441965	1.452083	1.441965

-0.059560	-0.059790	-0.058630	-0.055470	-0.052450
-0.049610	-0.046930	-0.044380	-0.041950	-0.039630
-0.034240	-0.029330	-0.024820	-0.020650	-0.016770
-0.013160	-0.009770	-0.006590	-0.003610	-0.000800
0.001850	0.004350	0.006710	0.008930	0.011030
0.013000	0.014870	0.016620	0.018260	0.019810
0.021250	0.022600	0.023850	0.025010	0.026090
0.027070	0.027980	0.028800	0.029530	0.030200
0.031150	0.032470	0.033130	0.033880	0.034720
0.035670	0.036770	0.038040	0.039560	0.041440
0.043990	0.050510	0.057020	0.059650	0.061610
0.063200	0.064550	0.065720	0.066760	0.067670
0.068490	0.069230	0.070750	0.071890	0.072800
0.073500	0.073990	0.074280	0.074370	0.074270
0.073960	0.073460	0.072750	0.071850	0.070740
0.069430	0.067910	0.066170	0.064200	0.062000
0.059550	0.056850	0.053860	0.050580	0.046980
0.043010	0.038650	0.033830	0.028480	0.022500
0.015770	0.008160	-0.000410	-0.009970	-0.014060
-0.018300	-0.022670	-0.027170	-0.031770	-0.036480
-0.041260	-0.046100	-0.050980	-0.056520	-0.059560

5.148000	5.148000	5.148000	5.148000	5.148000
5.148000	5.148000	5.148000	5.148000	5.148000
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5.148000	5.148000	5.148000	5.148000	5.148000
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5.148000	5.148000	5.148000	5.148000	5.148000
5.148000	5.148000	5.148000	5.148000	5.148000
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5.148000	5.148000	5.148000	5.148000	5.148000
5.148000	5.148000	5.148000	5.148000	5.148000
5.148000	5.148000	5.148000	5.148000	5.148000
5.148000	5.148000	5.148000	5.148000	5.148000
5.148000	5.148000	5.148000	5.148000	5.148000

B. RVC3D INPUT FILE FOR MODIFIED STATOR

```
'SSME HPTFP ADT FIRST STAGE STATOR'
 &nl1 im=301 jm=31 km=45 itl=95 iil=145 &end
 &nl2 nstg=4 cfl=4.0 avisc1=0.0 avisc2=1.5 avisc4=1.5 irs=1
      epi=0.75 epj=0.75 epk=0.75 ivdt=1 itmax=5000 &end
 &nl3 ibcin=3 ibcex=3 ires=1 iresti=0 iresto=1
      ibcpw=0 iqin=0 &end
 &nl4 igeom=1 ga=1.4 om=0.0 prat=0.665 emxx=0.2120 emty=0.0
      emrz=0.0 expt=0 alex=-67 &end
 &nl5 ilt=2 renr=864075.8 prnr=.7 tw=1.0 vispwr=.666666
      prtr=.9 cmutm=14.0 jedge=15 kedge=22 iltin=2 dblh=0.005
      dblt=0.005 &end
 &nl6 ixjb=0 oar=0. io1=1 io2=151 njo=1 nko=3 jo=1 ko=13 17 21 &end
```

C. SWIFT INPUT FOR MODIFIED STATOR

```
'SSME HPTFP ADT FIRST STAGE STATOR'
 &nl2 nstg=4 cfl=4.0 avisc1=0.0 avisc2=1.5 avisc4=1.5 irs=1
      eps=0.75 epi=1.0 epj=1.0 epk=1.0 pck=0.15 itmax=5000
      ivdt=1 ndis=1 refms=.2 ipc=0 &end
 &nl3 ibcin=3 ibcex=4 isymt=0 ires=1 iresti=0
      iresto=1 iqin=0 &end
 &nl4 igeom=1 ga=1.4 om=0.0 prat=0.665 expt=0.0 &end
 &nl5 ilt=2 renr=864075.8 prnr=0.7 tw=1.0 vispwr=.666666
      prtr=.9 cmutm=14.0 jedge=15 kedgh=22 kedgt=22 iltin=2
      dblh=0.005 dblt=0.005 hrough=4.0 itur=5 &end
 &nl6 oar=0.0 mioe=3 iqav=1 &end
  row    P0         Mx         Mt         Mr         T0
    0    1.0000     0.2120     0.0000     0.0000     1.0000
    1    0.9850     0.2850    -0.6720     0.0000     1.0000
```

D. MODIFIED STATOR FORT.10 FILE FOR SWIFT

```
 grid type   im   jm   km   i1   i2   i3  nin  nex nhub ntip  nlr  row   om  omh  omt
    1    2  135   32   57   12   62    0  999  999    0    0    0    1   1.   1.   0.
```

E. MODIFIED STATOR RESULTS

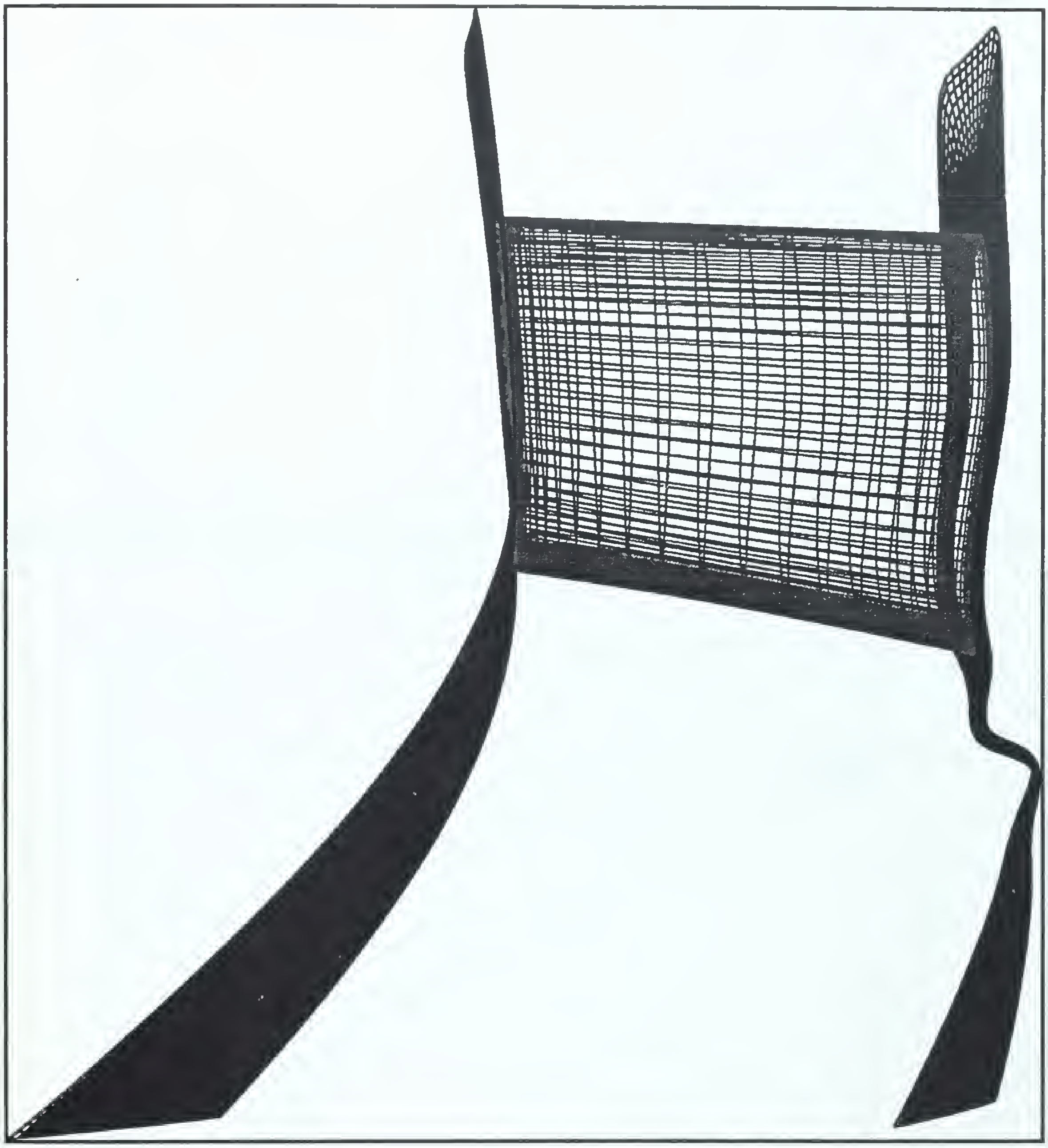

Figure A.1. Modified Stator Grid (301x31x45)

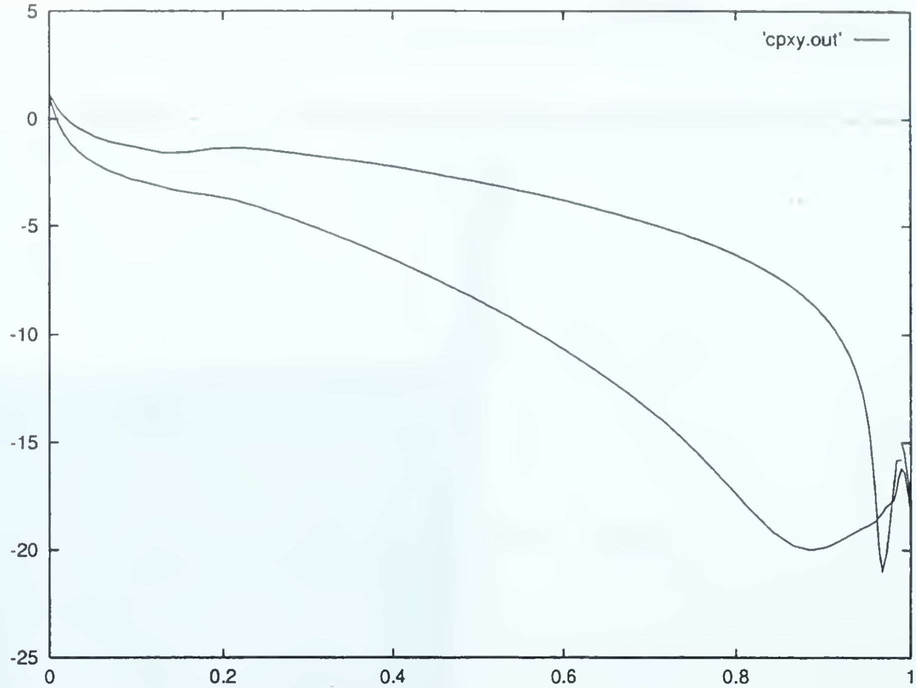

Figure A.2. RVC3D Solution of Coefficient of Pressure at Mid-Span for Modified Stator

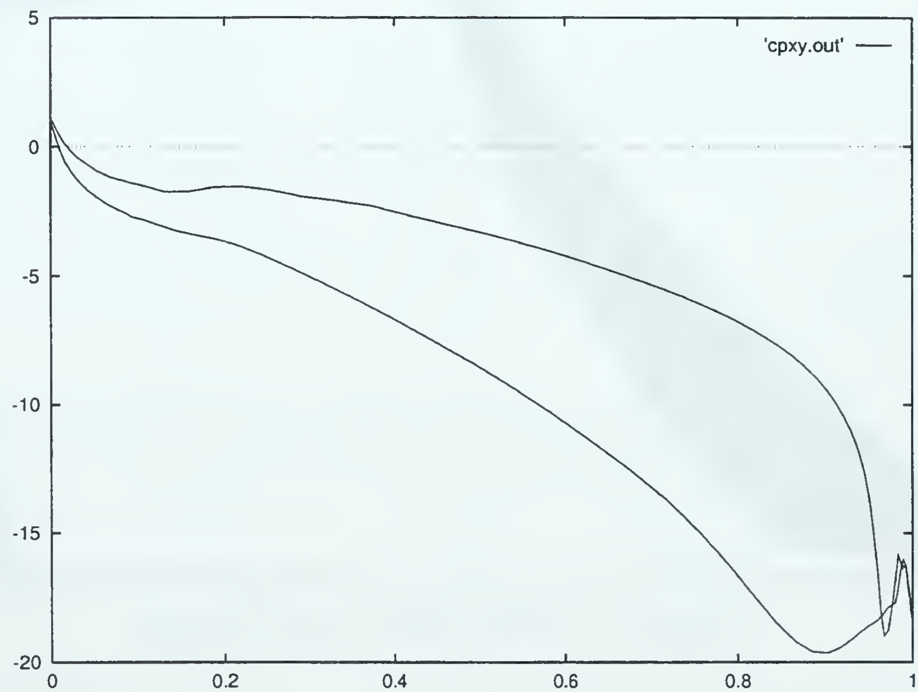

Figure A.3. SWIFT Solution of Coefficient of Pressure at Mid-Span for Modified Stator

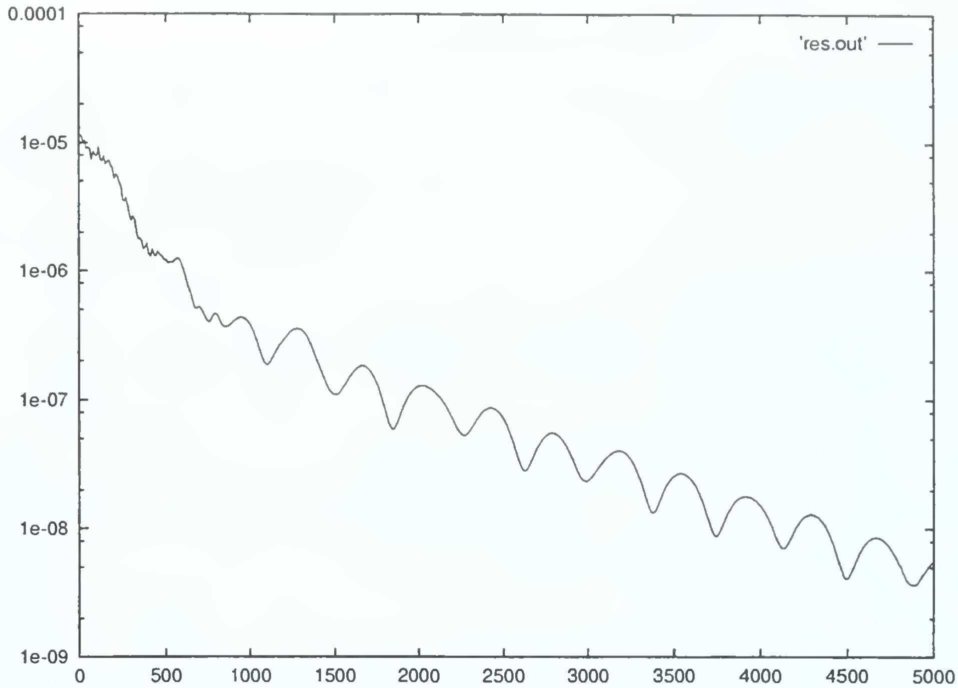

Figure A.4. RVC3D Residuals for Modified Stator

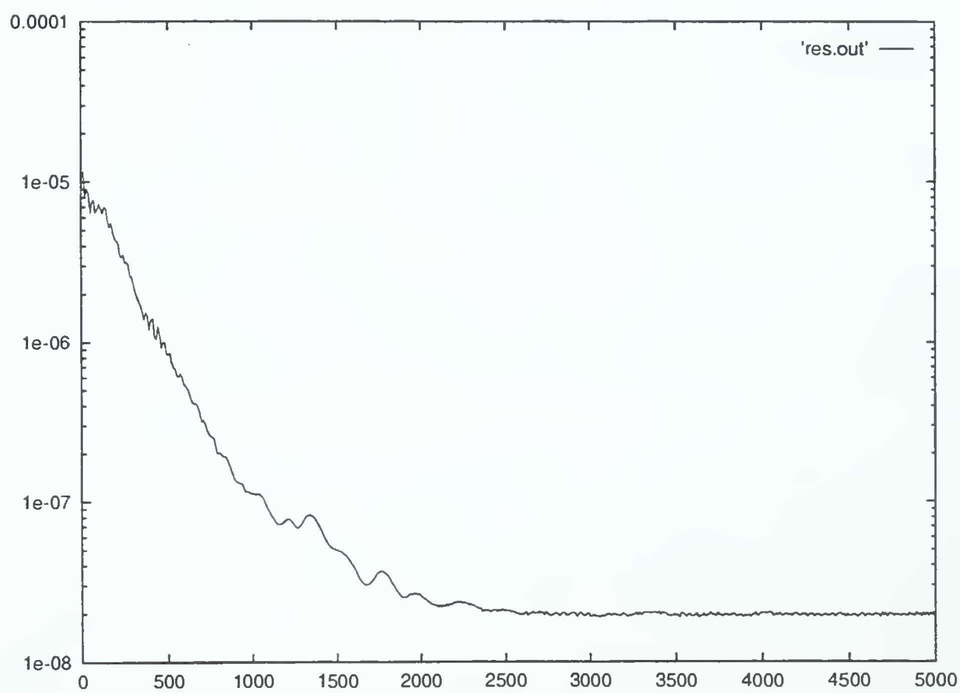

Figure A.5. SWIFT Residuals for Modified Stator

APPENDIX B. MGRID PROGRAM

The MGRID program is a Fortran program for repeating grid files circumferentially. The output can then be viewed in NASA's FAST program.

```
c-----------------------------------------------------------------------
c       Prog. reads an unformatted multigrid fort.1 file and produce
c       a multigrid file of n blades.  Change n to the desired number of
c       blades to be shown and change h to the number of blades on the
c       turbine or stator.
c-----------------------------------------------------------------------
        real x(300,100,100),y(300,100,100),z(300,100,100)
        real yy(300,100,100),zz(300,100,100)
        integer ni(200),nj(200),nk(200),h,l,n
c       open(unit=21,file='mgrid.dat',status='unknown')
        n=3
        h=50
        read(1) ngrid
        print *,ngrid
        read(1) (ni(igrid),nj(igrid),nk(igrid),igrid=1,ngrid)
        print *,(ni(igrid),nj(igrid),nk(igrid),igrid=1,ngrid)
        l=n*ngrid
        write(521)l
        print *,  l
        write(521)((ni(igrid),nj(igrid),nk(igrid),m=1,n),igrid=1,ngrid)
        print *,  ((ni(igrid),nj(igrid),nk(igrid),m=1,n),igrid=1,ngrid)
        do igrid=1,ngrid
           read(1)(((x(i,j,k),
     #             i=1,ni(igrid)),j=1,nj(igrid)),k=1,nk(igrid)),
     #          (((y(i,j,k),
     #             i=1,ni(igrid)),j=1,nj(igrid)),k=1,nk(igrid)),
     #          (((z(i,j,k),
     #             i=1,ni(igrid)),j=1,nj(igrid)),k=1,nk(igrid))
           pid2=acos(0.0)
           do m=1,n
              bang=(m-2)*4.*pid2/h-2.*pid2/h
              do k=1,nk(igrid)
                 do i=1,ni(igrid)
                    do j=1,nj(igrid)
                       yy(i,j,k)=y(i,j,k)*cos(bang)+z(i,j,k)*sin(bang)
                       zz(i,j,k)=-y(i,j,k)*sin(bang)+z(i,j,k)*cos(bang)
                    enddo
                 enddo
              enddo
              write(521)(((x(i,j,k),
     #                 i=1,ni(igrid)),j=1,nj(igrid)),k=1,nk(igrid)),
     #              (((yy(i,j,k),
     #                 i=1,ni(igrid)),j=1,nj(igrid)),k=1,nk(igrid)),
     #              (((zz(i,j,k),
     #                 i=1,ni(igrid)),j=1,nj(igrid)),k=1,nk(igrid))
           enddo
        enddo
        stop
        end
```

APPENDIX C. COMBINED NUMERICAL INPUT FILES

A. NEW TCGRID INPUT FOR COMBINED STATOR AND ROTOR

1. Stator.in File for New TCGRID

```
 &nam1 merid=0 'im=135 jm=31 km=57 it1=12 icap=12  igc1t=0
       kmt=13 jmt=13 &end
 &nam2 n1e=19 nte=16 ds1e=0.010 dste=0.0050 dshub=0.0001
       dstip=0.0001 dswte=0.005 dswex=0.03 dsthr=1.0 dsmin=0.001
       dsmax=0.005 rcorn=.098 c1tip=.045 dsc1t=.0001 &end
 &nam3 iterm=150 idbg=0 0 0 0 0 0 0 0 0 aabb=1.0 &end
 &nam4 zbc=0.0000 0.0000 1.5000 0.0000 0.0000 1.5000
       rbc=4.0788 4.0788 4.0788 5.1480 5.1480 5.02425 &end
 &nam5 iswift=1 dslap=.005 &end
'new data style with z,th,r format SSME HPFTP ** COURSE GRID **'
 58  58
   -0.9334116      -0.8467470      -0.7600824      -0.6734079      -0.5867434
   -0.5000787      -0.4134042      -0.3267396      -0.2400750      -0.1534005
   -6.6735901e-02  1.9928699e-02   0.1066032       0.1932678       0.2799324
    0.3666069       0.4532715       0.5399361       0.6266007       0.6927030
    0.7100379       0.7360452       0.7577163       0.7837138       0.8097210
    0.8313921       0.8530533       0.8790606       0.9007317       0.9267291
    0.9527364       0.9787437       1.004741        1.035075        1.061082
    1.082743        1.193148        1.216443        1.239866        1.263398
    1.287020        1.310730        1.334510        1.358349        1.382228
    1.406137        1.430055        1.578555        1.617592        1.620448
    1.622869        1.624487        1.625055        1.625623        1.627241
    1.629662        1.632517        1.750000

    3.790294        3.815232        3.838923        3.861406        3.882691
    3.902798        3.921746        3.939557        3.956248        3.971821
    3.986304        3.999689        4.012004        4.023261        4.033448
    4.042595        4.050704        4.057773        4.063811        4.067732
    4.068662        4.069979        4.070999        4.072147        4.073206
    4.074018        4.074761        4.075573        4.076187        4.076830
    4.077384        4.077850        4.078216        4.078533        4.078711
    4.078780        4.078800        4.078800        4.078800        4.078800
    4.078800        4.078800        4.078800        4.078800        4.078800
    4.078800        4.078800        4.078800        4.078800        4.078800
    4.078800        4.078800        4.078800        4.078800        4.078880
    4.078800        4.078800        4.078800

   -0.9334116      -0.8467470      -0.7600824      -0.6734079      -0.5867434
   -0.5000787      -0.4134042      -0.3267396      -0.2400750      -0.1534005
   -6.6735901e-02  1.9928699e-02   0.1066032       0.1932678       0.2799324
    0.3666069       0.4532715       0.5399361       0.6266007       0.6875550
    0.7114734       0.7353819       0.7592607       0.7830999       0.8068797
    0.8305902       0.8542116       0.8777439       0.9011673       0.9244521
```

0.9513306	0.9781992	1.005068	1.031936	1.058805
1.085674	1.193148	1.216443	1.239866	1.263398
1.287020	1.310730	1.334510	1.358349	1.382228
1.406137	1.430055	1.578555	1.617592	1.620448
1.622869	1.624487	1.625055	1.625623	1.627241
1.629662	1.632517	1.750000		

5.148000	5.148000	5.148000	5.148000	5.148000
5.148000	5.148000	5.148000	5.148000	5.148000
5.148000	5.148000	5.148000	5.148000	5.148000
5.148000	5.148000	5.148000	5.148000	5.148000
5.147713	5.146842	5.145396	5.143377	5.140783
5.137615	5.133873	5.129556	5.124685	5.119240
5.112617	5.105697	5.099371	5.092748	5.086125
5.079502	5.053010	5.047565	5.042694	5.038377
5.034636	5.031467	5.028873	5.026854	5.025408
5.024538	5.024250	5.024250	5.024250	5.024818
5.026436	5.028857	5.031713	5.094268	5.096689
5.098307	5.098875	5.098875		

6 105 52

1.253538	1.245321	1.237104	1.228887	1.220670
1.212453	1.204236	1.196019	1.187802	1.179585
1.159042	1.138500	1.117958	1.097415	1.076872
1.056330	1.035787	1.015245	0.994703	0.974160
0.953618	0.933075	0.912533	0.891990	0.871448
0.850905	0.830362	0.809820	0.789277	0.768735
0.748192	0.727650	0.707107	0.686565	0.666022
0.645480	0.624937	0.604395	0.583853	0.563310
0.542768	0.522225	0.514008	0.505791	0.497574
0.489357	0.481140	0.472923	0.464706	0.456489
0.448272	0.440055	0.448272	0.456489	0.464706
0.472923	0.481140	0.489357	0.497574	0.505791
0.514008	0.522225	0.542768	0.563310	0.583853
0.604395	0.624937	0.645480	0.666022	0.686565
0.707107	0.727650	0.748192	0.768735	0.789277
0.809820	0.830362	0.850905	0.871448	0.891990
0.912533	0.933075	0.953618	0.974160	0.994703
1.015245	1.035787	1.056330	1.076872	1.097415
1.117958	1.138500	1.159042	1.179585	1.187802
1.196019	1.204236	1.212453	1.220670	1.228887
1.237104	1.245321	1.253538	1.261755	1.253538

-0.091840	-0.092470	-0.092070	-0.090110	-0.086510
-0.083090	-0.079820	-0.076700	-0.073720	-0.070860
-0.064230	-0.058240	-0.052800	-0.047850	-0.043320
-0.039170	-0.035340	-0.031820	-0.028560	-0.025530
-0.022730	-0.020120	-0.017690	-0.015430	-0.013320
-0.011340	-0.009500	-0.007770	-0.006150	-0.004630
-0.003200	-0.001860	-0.000610	0.000580	0.001680
0.002730	0.003710	0.004630	0.005490	0.006310
0.007360	0.008800	0.009500	0.010300	0.011190

0.012200	0.013360	0.014700	0.016280	0.018230
0.020880	0.027530	0.034180	0.036830	0.038780
0.040360	0.041700	0.042850	0.043870	0.044760
0.045550	0.046260	0.047700	0.048750	0.049580
0.050210	0.050640	0.050880	0.050910	0.050720
0.050320	0.049700	0.048850	0.047760	0.046430
0.044850	0.043010	0.040910	0.038520	0.035850
0.032870	0.029580	0.025960	0.022000	0.017680
0.012970	0.007860	0.002330	-0.003670	-0.010140
-0.017150	-0.024720	-0.032930	-0.041850	-0.045640
-0.049570	-0.053650	-0.057880	-0.062290	-0.066880
-0.071670	-0.076690	-0.081950	-0.088230	-0.091840

4.078800	4.078800	4.078800	4.078800	4.078800
4.078800	4.078800	4.078800	4.078800	4.078800
4.078800	4.078800	4.078800	4.078800	4.078800
4.078800	4.078800	4.078800	4.078800	4.078800
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1.087881	1.066289	1.044698	1.023106	1.001504
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0.763973	0.742371	0.720779	0.699188	0.677596
0.655994	0.634402	0.612810	0.591218	0.569616
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0.768963	0.794267	0.819562	0.844866	0.870170
0.895465	0.920769	0.946074	0.971368	0.996673
1.021967	1.047271	1.072576	1.097870	1.123175
1.148479	1.173774	1.199078	1.224373	1.249677
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1.421719	1.431837	1.441965	1.452083	1.441965

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0.021250	0.022600	0.023850	0.025010	0.026090
0.027070	0.027980	0.028800	0.029530	0.030200
0.031150	0.032470	0.033130	0.033880	0.034720
0.035670	0.036770	0.038040	0.039560	0.041440
0.043990	0.050510	0.057020	0.059650	0.061610
0.063200	0.064550	0.065720	0.066760	0.067670
0.068490	0.069230	0.070750	0.071890	0.072800
0.073500	0.073990	0.074280	0.074370	0.074270
0.073960	0.073460	0.072750	0.071850	0.070740
0.069430	0.067910	0.066170	0.064200	0.062000
0.059550	0.056850	0.053860	0.050580	0.046980
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-0.018300	-0.022670	-0.027170	-0.031770	-0.036480
-0.041260	-0.046100	-0.050980	-0.056520	-0.059560

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2. Rotortip.in File for New TCGRID

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       dstip=.0001 dswte=.005 dswex=.03 dsthr=1.0 dsmin=.001
       dsmax=.005 rcorn=0 cltip=.045 dsclt=.0001 &end
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 &nam4 zbc=1.5     1.5     2.65    1.5      2.65     3.0
       rbc=4.0788  4.0788  4.0788  5.02425  5.02425  5.098875  &end
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'SSME HPFTP ADT FIRST STAGE ROTOR'
 58  58
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-0.5000787      -0.4134042      -0.3267396      -0.2400750      -0.1534005
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 0.7100379       0.7360452      0.7577163       0.7837138       0.8097210
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 0.9527364       0.9787437      1.004741        1.035075        1.061082
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 1.287020        1.310730       1.334510        1.358349        1.382228
 1.406137        1.430055       1.578555        1.617592        1.620448
 1.622869        1.624487       1.625055        1.625623        1.627241
 1.629662        1.632517       1.750000

 3.790294        3.815232       3.838923        3.861406        3.882691
 3.902798        3.921746       3.939557        3.956248        3.971821
 3.986304        3.999689       4.012004        4.023261        4.033448
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 4.074018        4.074761       4.075573        4.076187        4.076830
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 4.078780        4.078800       4.078800        4.078800        4.078800
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5 105 50

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-0.006020	-0.003280	-0.000270	0.003040	0.006650
0.010580	0.014870	0.019540	0.024630	0.030190
0.036280	0.038880	0.041580	0.044400	0.047330
0.050380	0.053550	0.054910	0.055170	0.054680

4.556475	4.556475	4.556475	4.556475	4.556475
4.556475	4.556475	4.556475	4.556475	4.556475
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4.556475	4.556475	4.556475	4.556475	4.556475
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4.556475	4.556475	4.556475	4.556475	4.556475
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4.556475	4.556475	4.556475	4.556475	4.556475

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2.399542	2.405482	2.399542	2.393602	2.387662
2.381722	2.375782	2.369842	2.363902	2.357962
2.352022	2.346082	2.331232	2.316382	2.301532
2.286682	2.271832	2.256982	2.242132	2.227282
2.212432	2.197582	2.182732	2.167882	2.153032
2.138182	2.123332	2.108482	2.093632	2.078782
2.063932	2.049082	2.034232	2.019382	2.004532
1.989682	1.974832	1.959982	1.945132	1.930282
1.915432	1.900582	1.885732	1.870882	1.864942
1.859002	1.853062	1.847122	1.841182	1.835242
1.829302	1.823362	1.817422	1.811482	1.817422
1.823362	1.829302	1.835242	1.841182	1.847122
1.853062	1.859002	1.864942	1.870882	1.885732
1.900582	1.915432	1.930282	1.945132	1.959982
1.974832	1.989682	2.004532	2.019382	2.034232
2.049082	2.063932	2.078782	2.093632	2.108482
2.123332	2.138182	2.153032	2.167882	2.182732
2.197582	2.212432	2.227282	2.242132	2.256982
2.271832	2.286682	2.301532	2.316382	2.331232
2.346082	2.352022	2.357962	2.363902	2.369842
2.375782	2.381722	2.387662	2.393602	2.399542
0.046150	0.043810	0.039360	0.035390	0.031450
0.027570	0.023730	0.019950	0.016220	0.012560
0.008950	0.005410	-0.003130	-0.011200	-0.018740
-0.025740	-0.032150	-0.037970	-0.043220	-0.047900
-0.052040	-0.055690	-0.058880	-0.061650	-0.064050
-0.066120	-0.067860	-0.069310	-0.070480	-0.071380
-0.072010	-0.072380	-0.072500	-0.072360	-0.071970
-0.071320	-0.070410	-0.069230	-0.067780	-0.066040
-0.064010	-0.061650	-0.058950	-0.055870	-0.054530
-0.053120	-0.051640	-0.050090	-0.048440	-0.046700
-0.044830	-0.042790	-0.040240	-0.035600	-0.031200
-0.029630	-0.028610	-0.027920	-0.027470	-0.027230
-0.027160	-0.027210	-0.027340	-0.027550	-0.028380
-0.029480	-0.030430	-0.031170	-0.031720	-0.032070
-0.032220	-0.032170	-0.031930	-0.031490	-0.030860
-0.030030	-0.029010	-0.027800	-0.026380	-0.024780
-0.022970	-0.020960	-0.018750	-0.016340	-0.013710
-0.010870	-0.007800	-0.004520	-0.001000	0.002770
0.006780	0.011060	0.015620	0.020470	0.025640
0.031160	0.033470	0.035840	0.038270	0.040780
0.043350	0.045700	0.046510	0.046630	0.046150
4.795312	4.795312	4.795312	4.795312	4.795312
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2.367308	2.372258	2.367308	2.362358	2.357408
2.352458	2.347508	2.342558	2.337608	2.332658
2.327708	2.322758	2.310383	2.298008	2.285633
2.273258	2.260883	2.248508	2.236133	2.223758
2.211383	2.199008	2.186633	2.174258	2.161883
2.149508	2.137133	2.124758	2.112383	2.100008
2.087633	2.075258	2.062883	2.050508	2.038133
2.025758	2.013383	2.001008	1.988633	1.976258
1.963883	1.951508	1.939133	1.926758	1.921808
1.916858	1.911908	1.906958	1.902008	1.897058
1.892108	1.887158	1.882208	1.877258	1.882208
1.887158	1.892108	1.897058	1.902008	1.906958
1.911908	1.916858	1.921808	1.926758	1.939133
1.951508	1.963883	1.976258	1.988633	2.001008
2.013383	2.025758	2.038133	2.050508	2.062883
2.075258	2.087633	2.100008	2.112383	2.124758
2.137133	2.149508	2.161883	2.174258	2.186633
2.199008	2.211383	2.223758	2.236133	2.248508
2.260883	2.273258	2.285633	2.298008	2.310383
2.322758	2.327708	2.332658	2.337608	2.342558
2.347508	2.352458	2.357408	2.362358	2.367308
0.038110	0.036140	0.032570	0.029390	0.026220
0.023060	0.019930	0.016810	0.013710	0.010640
0.007590	0.004560	-0.002870	-0.010090	-0.017030
-0.023650	-0.029890	-0.035660	-0.040930	-0.045660
-0.049840	-0.053490	-0.056660	-0.059410	-0.061810
-0.063900	-0.065720	-0.067290	-0.068630	-0.069760
-0.070690	-0.071420	-0.071970	-0.072330	-0.072510
-0.072520	-0.072340	-0.071980	-0.071430	-0.070690
-0.069740	-0.068570	-0.067180	-0.065530	-0.064800
-0.064010	-0.063180	-0.062300	-0.061340	-0.060280
-0.059090	-0.057690	-0.055900	-0.052310	-0.048780
-0.047520	-0.046700	-0.046140	-0.045730	-0.045430
-0.045200	-0.045040	-0.044940	-0.044880	-0.044930

-0.045190	-0.045380	-0.045390	-0.045210	-0.044860
-0.044320	-0.043600	-0.042690	-0.041610	-0.040350
-0.038900	-0.037280	-0.035480	-0.033500	-0.031340
-0.029000	-0.026490	-0.023810	-0.020950	-0.017920
-0.014710	-0.011340	-0.007790	-0.004080	-0.000200
0.003850	0.008060	0.012430	0.016960	0.021660
0.026510	0.028500	0.030510	0.032540	0.034600
0.036690	0.038110	0.038550	0.038550	0.038110

5.034150	5.034150	5.034150	5.034150	5.034150
5.034150	5.034150	5.034150	5.034150	5.034150
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5.034150	5.034150	5.034150	5.034150	5.034150
5.034150	5.034150	5.034150	5.034150	5.034150

B. SWIFT INPUT

1. SWIFT Input for Combined Stator, Rotor and Tip

```
'SSME HPTFP ADT FIRST STAGE STATOR AND ROTOR'
 &nl2 nstg=2 cfl=2.0 avisc1=0.0 avisc2=0.5 avisc4=2.0 irs=1
      eps=2.0 pck=0.15 itmax=100 ivdt=1 ndis=2
      refms=.2 ipc=0 &end
 &nl3 ibcin=3 ibcex=4 isymt=0 ires=1 iresti=1
      iresto=1 iqin=0 kbcor=1 &end
 &nl4 igeom=1 ga=1.4 om=-.03809 prat=0.3 expt=0.0 &end
 &nl5 ilt=2 renr=564075.8 prnr=0.7 tw=0.0 vispwr=.666666
      prtr=.9 cmutm=14.0 jedge=15 kedgh=22 kedgt=22 iltin=2
      dblh=0.005 dblt=0.005 hrough=4.0 itur=5 &end
 &nl6 oar=0.0 mioe=3 iqav=1 &end
  row      P0         Mx         Mtheta      Mr         T0
    0      1.0000     0.2120      0.0000     0.0000     1.0000
    1      0.9850     0.1980     -0.6720     0.0000     1.0000
    2      0.3300     0.1928     -0.2298     0.0000     0.9600
```

2. Combined Stator, Rotor and Tip Input File for SWIFT

grid	type	im	jm	km	i1	i2	i3	nin	nex	nhub	ntip	nlr	row	om	omh	omt
1	2	135	32	57	12	62	0	999	-2	0	0	0	1	0.	0.	0.
2	2	235	32	57	62	112	45	-1	999	0	3	0	2	1.	1.	0.
3	3	113	13	13	0	0	45	0	0	0	2	0	2	1.	1.	0.

APPENDIX D. SSME DATA

SSME Data

Date	File Name	Press Ratio	Mass Flow	Eficency	Ref RPM	Mass Flow Vena	Ref HP	Ref Press Ratio	Ref Temp ratio	HP	HP	HP	Mass Flow	Flange Mass Flow Avg
02/27/98		1.31611595	2.835727662	51.79298771	4901.604375	2.220951535	16.9057989	1.324667519	1.037484099	23.74515138	23.23400269	21.01663437	17.12320365	9.979465654
02/27/98		1.236057905	2.836998997	65.3530735	4884.17546	2.238219948	17.12016972	1.325911946	1.046064017	24.3509413	23.74548324	20.99456287	17.06799852	9.952498758
02/27/98		1.274333235	2.826152523	56.70193764	4863.787541	2.234725785	16.94553648	1.323402598	1.046455168	24.00293991	23.46755973	20.68309818	17.04660827	9.936380397
03/03/98		1.232490422	2.859842801	67.13543678	4875.820115	2.246559702	16.84550571	1.321963883	1.038473439	23.48355954	23.12592091	21.14285104	16.12178047	9.490811633
03/03/98		1.314426648	2.915561869	50.59463234	4869.243135	2.303473769	16.93577201	1.321500707	1.044067096	24.10508536	23.36688428	21.28097456	16.08700479	9.501283331
03/05/98		1.090505374	1.634678656	76.89398237	3017.932098	1.507558846	4.468019015	1.113085976	1.026527509	5.373338032	5.105218285	5.704092915	11.81608403	6.725381344
03/05/98		1.236567681	2.888261402	67.24499914	4904.457554	2.271820522	17.169113	1.31787125	1.036598332	24.32800961	23.45477918	21.63721947	16.03439535	9.461328378
03/05/98		1.292060178	2.883574477	54.36355013	4867.328309	2.287215746	16.95630119	1.31596608	1.043808081	23.9153219	23.2914471	21.23653921	15.97670881	9.430141643
03/05/98		1.310507781	2.927669397	51.59109334	4865.238587	2.310608065	16.78126211	1.32171303	1.043137176	23.8026202	23.13679591	21.52292605	16.0721283	9.49989885
03/10/98		1.110220971	1.631912866	56.97618575	2915.343092	1.51593576	3.967814873	1.117266138	1.037864047	5.10081751	4.600728589	5.191853455	11.49671152	6.564312193
03/10/98	0310fwd1.10d	1.318741227	2.893530236	50.40296152	4862.108136	2.280801584	16.81463037	1.326250886	1.045406432	23.71738904	23.31300087	21.33715206	16.01883643	9.456183334
03/10/98	0310fwd1.20d	1.318550494	2.831534974	50.08449572	4839.044218	2.235802007	16.65134609	1.326157431	1.047144207	23.89104487	23.12335917	20.80664296	15.97569963	9.403717303
04/06/98		1.116650704	1.710329283	57.25308531	2983.484418	1.583861585	4.24717723	1.116626839	1.034059565	5.325180144	4.904039984	5.722834347	11.72551832	6.7179238
04/06/98	0406fwd1.r01	1.315992087	2.879501865	50.04775989	4822.15542	2.282882988	16.41279382	1.315806454	1.043177713	23.11441049	22.52852851	20.84204486	15.97090855	9.425205207
04/06/98	o406fwd2.r01	1.316748521	2.876860689	50.1074523	4822.798575	2.279615783	16.47080619	1.316601641	1.043271192	23.18898968	22.62384749	20.89344322	15.95489931	9.415879998
04/06/98	0406fwd3.r01	1.31733882	2.785422438	49.76647648	4829.375697	2.205796592	16.44098321	1.317236151	1.043129033	23.0739208	22.59068813	20.11767739	15.96684768	9.376135047
04/06/98	0406ctr.r01	1.31659914	2.749282513	49.93735787	4837.318041	2.178372515	16.53533197	1.316439325	1.043070412	23.00566588	22.70530769	19.88357449	15.96157598	9.355429235
04/10/98		1.033834915	1.171116923	111.5863709	1507.958139	1.165711991	0.595852364	1.033731263	1.028960394	0.731737629	0.633789406	2.305821322	10.86436722	6.01774207
04/10/98		1.115814254	1.595018173	58.51799285	2968.272266	1.48128337	4.187951873	1.115445347	1.035907095	5.370669648	4.83916896	5.437818509	17.2089102	9.401964188
04/10/98	0410fwd	1.319630026	2.342399859	51.4410152	4830.89305	1.866414044	16.61516408	1.319206715	1.051138187	23.57750203	23.03972555	17.86435173	19.307284	10.82484193
04/10/98	0410fwd	1.317883366	2.515229289	51.5963167	4818.071614	2.008370054	16.55333819	1.317440088	1.051954679	23.69859982	22.94106059	19.16180998	19.30335446	10.90929188
04/10/98	0410fwd	1.312393778	2.886517561	49.33105383	4781.914703	2.303161309	16.12037772	1.312235302	1.047036614	23.05125015	22.1487285	20.54733403	15.65965599	9.373086774
04/10/98	0410ctr	1.318326851	2.934466589	49.85737097	4839.729605	2.326923595	16.59378332	1.318372998	1.045421082	23.20506848	22.87046361	21.38202066	15.95886237	9.446664481
04/10/98	0410ctr	1.318854771	2.891548995	50.06270614	4839.742159	2.293269549	16.62583716	1.318900937	1.046012142	23.3377976	22.93677872	21.20948955	15.94096529	9.416257141
04/10/98	0410ctr	1.318350102	2.814250042	49.84755159	4834.313259	2.232409388	16.65142663	1.318398412	1.045822136	23.31453965	22.95915761	20.56017818	15.93868557	9.376467804
05/01/98		1.117025772	1.678719618	53.32479303	2988.68627	1.569317471	4.270727308	1.111450022	1.039016832	5.450829109	4.931901157	5.297770071	11.75626863	6.717494121
05/01/98	0501fwd1	1.316237383	2.910875657	49.6317248	4803.571503	2.316773353	16.41274591	1.309940079	1.042584647	22.7633536	22.41527139	20.88385442	15.85539139	9.383133523
05/01/96	0501fwd2	1.316152253	2.837444891	49.21975696	4807.849893	2.264805857	16.42026797	1.309935037	1.045570455	22.91286118	22.48968133	20.29926024	15.84281458	9.340129738
05/01/98	0510fwd3	1.316561485	2.89039245	49.32663117	4806.136234	2.307307369	16.40151408	1.310622456	1.046227771	23.0223736	22.48991374	20.77158448	15.83669917	9.36354581
05/01/98	0510ctr1	1.316131424	2.902505126	49.93116847	4797.123624	2.324150487	16.35279327	1.310116652	1.049062145	23.11219047	22.47517743	21.20458871	15.78917782	9.345841472

Table D.1. SSME Data

APPENDIX E. TTR DATA

TTR Data (1 of 2)

Date	File Name	Tar	Cal (in H_2O)	P2 (in H2O)	P3 (in H2O)	P4 (in H2O)	P31 (in H2O)	P32 (in H2O)	P33 (in H2O)	P34 (in H2O)	hw vena(in-H2O)		Ref Temp (C)	TT2 (R)
2/27/98		-0.30566667	135.920667	131.682333	23.7953333	131.708333	2.33633333	-0.53	-0.53066667	179.293667	-0.573	3.313	24.18863769	558.257779
2/27/98		-9.109	135.723	123.497667	15.1053333	123.411	20.4493333	-9.32533333	-9.33266667	170.894333	-9.38366667	3.342	26.46913387	567.479583
2/27/98		-13.7806667	135.603667	117.320667	10.2343333	117.719	1.87633333	-13.9936667	-14.007	165.209333	-14.045	3.313	27.61530026	567.961314
3/3/98		0.32933333	136.004667	131.412	23.1193333	131.244	29.8476667	0.02066667	-0.04366667	149.116	-0.129	3.36566667	20.76118148	559.446074
3/3/98		-13.5926667	135.903667	117.355333	9.42533333	117.133667	-11.4043333	-13.6876667	-13.6793333	135.202	-13.7393333	3.512	22.67594027	565.419513
3/5/98		0.377	135.67	48.6446667	7.51533333	48.4656667	10.903	0.194	0.16566667	67.8196667	0.09433333	1.07733333	19.32008849	546.49288
3/5/98		-2.102	135.549	129.033667	17.559	129.255	26.739	-2.66833333	-2.74433333	145.815667	-2.923	3.45566667	19.6695513	557.356273
3/5/98		-18.9446667	135.390667	111.259	0.85966667	111.637667	-9.315	-19.0736667	-19.0703333	128.336667	-19.1126667	3.45266667	23.13161431	565.118111
3/5/98		-17.575	135.275	112.809333	1.96466667	113.237667	-14.0983333	-17.7196667	-17.731	130.267333	-17.7673333	3.53333333	24.85598676	564.437372
3/10/98		-5.09233333	135.463333	40.1603333	1.39633333	40.0233333	-5.22733333	-5.25766667	-5.27933333	57.7606667	-5.33666667	124.812667	32.98168373	575.20687
3/10/98	0310fwd1.10d	-17.679	135.36	112.862333	1.69	112.464667	-17.8776667	-17.8813333	-17.909	128.709	-17.956	3.45666667	25.20752853	566.905547
3/10/98	0310fwd1.20d	-20.1606667	135.350667	109.615333	-0.886	109.945	-20.329	-20.334	-20.3443333	125.209	-20.385	3.30933333	25.58646914	568.779767
4/6/98		-2.87566667	135.116667	44.353	3.935	44.424	-3.00666667	-3.02433333	-3.043	63.2203333	-3.086	1.17866667	24.38540986	554.531662
4/6/98	0406fwd1.r01	-13.6386667	135.064667	114.782	5.26766667	114.65	-13.8183333	-13.8206667	-13.8323333	131.393333	-13.869	3.415	26.28843433	564.408972
4/6/98	0406fwd2.r01	-14.2	135.031	114.458333	4.70766667	114.412	-14.3676667	-14.3643333	-14.37	130.554667	-14.409	3.41066667	26.38113007	564.523987
4/6/98	0406fwd3.r01	-14.5763333	135.060333	114.003667	4.397	114.293667	-14.7303333	-14.7303333	-14.7363333	130.384	-14.7576667	3.19266667	26.43453863	564.330588
4/6/98	0406ctr.r01	-15.964	135.051	112.310333	2.62433333	112.582	-16.1356667	-16.139	-16.155	128.978333	-16.1843333	3.11133333	26.60339479	564.342993
4/10/98		1.02866667	135.506333	14.8266667	3.192	14.6083333	0.852	0.83266667	0.808	56.5306667	0.76333333	0.54533333	23.52551799	548.996449
4/10/98		-1.672	135.468	45.3463333	4.63933333	45.1336667	-1.94233333	-1.97533333	-2.01766667	180.689667	-2.08166667	1.03066667	24.22951327	556.489395
4/10/98	0410fwd1	-11.0986667	135.422667	117.933	7.83533333	118.559	-11.365	-11.4183333	-11.4486667	344.384333	-11.5286667	2.29633333	25.89345899	572.934771
4/10/98	0410fwd2	-12.588	135.416	117.931	6.57833333	116.351333	-12.8606667	-12.8823333	-12.9213333	341.964	-13.0036667	2.65366667	26.03438345	573.895804
4/10/98	0410fwd3	-16.862	135.41	110.158	1.87266667	109.961	-17.047	-17.0546667	-17.083	125.996667	-17.1133333	3.444	26.45161129	568.637294
4/10/98	0410ctr1	-17.268	135.331	112.134667	1.686	112.050667	-17.3896667	-17.3746667	-17.39	128.4	-17.3966667	3.56366667	27.36535955	566.816932
4/10/98	0410ctr2	-17.9073333	135.286333	111.722667	0.91	111.626	-18.029	-18.0193333	-18.032	127.624667	-18.0506667	3.46433333	27.81185216	567.499438
4/10/98	0410ctr3	-17.8636667	135.293667	111.408667	1.05533333	111.465333	-17.9846667	-17.9683333	-17.997	127.327333	-18.0006667	3.27466667	28.04440393	567.326092
5/1/98		-5.18633333	135.556333	41.982	-0.13066667	41.9653333	-5.38133333	-5.39333333	-5.424	62.0933333	-5.46933333	1.14666667	25.4704821	559.927354
5/1/98	0501fwd1	-10.069	135.516	117.678	5.41766667	117.723333	-10.2476667	-10.246	-10.2593333	133.483667	-10.2936667	3.512	26.65992089	563.780032
5/1/98	0501fwd2	-14.543	135.457	113.279	0.85666667	113.179333	-14.765	-14.764	-14.778	129.294333	-14.8326667	3.34533333	27.69575247	567.004295
5/1/98	0501fwd3	-15.4416667	135.446667	111.926667	0.07733333	112.533	-15.6043333	-15.5966667	-15.61	128.576333	-15.624	3.478	27.98953695	567.733042
5/1/98	0501ctr1	-16.8166667	135.386667	111.343333	-0.641	110.952333	-17.0033333	-16.9966667	-17.0243333	126.973	-17.0506667	3.52533333	29.06506173	570.817349

Table E.1. TTR Data (1 of 2)

TTR Data (2 of 2)

Date	File Name	TT3	TT4	Water Inlet	Water Outlet	Orifice Temp	RPM	GPM	Tq (in-lbs)	radial pos	swirl angle	throttle pos	atm press (in Hg)
2/27/98		558.371837	538.48851	537.279247	546.333271	571.379786	5085.3366	13.3490713	287.950068	1.04511719	0.43945313	-0.37591797	29.92
2/27/98		567.695292	545.793832	541.293492	550.899104	575.973053	5109.1602	12.9035284	292.916844	0.18574219	66.5332031	0.15538086	29.92
2/27/98		568.06266	546.4593	540.116373	549.398347	575.420303	5089.7356	13.1626058	290.593278	0.89863281	40.2539063	-0.03600098	29.92
3/3/98		559.314181	537.607902	538.589291	547.532653	570.439133	5063.40968	13.3653672	287.851716	0.90351563	-2.63671875	1.38650879	29.92
3/3/98		565.425434	543.926819	541.05772	550.16626	572.752566	5083.81654	13.470313	289.683522	0.82539063	10.2832031	1.49791016	29.92
3/5/98		546.676424	538.308379	532.345543	534.705591	564.823116	3097.99032	11.5888709	103.859712	0.94746094	2.4609375	1.03230957	29.765
3/5/98		557.36748	535.2998	539.88301	549.30411	570.68835	5083.95252	13.143854	290.765394	0.94746094	2.54882813	4.63714355	29.765
3/5/98		565.165819	543.453241	542.1075	551.391869	572.746788	5080.55662	13.1111743	288.933588	0.86933594	6.24023438	4.63714355	29.765
3/5/98		564.394052	542.765572	541.581304	550.900893	571.306461	5075.11124	13.0000727	287.323074	0.78632813	25.4003906	1.9863623	29.92
3/10/98		575.227595	565.74395	551.721137	554.009943	586.930225	3020.55898	11.0596747	103.318776	1.51386719	-40.6933594	-0.32164551	30.121
3/10/98	0310fwd1.10d	566.842572	545.157558	539.79937	549.346665	575.971755	5082.87912	12.6445781	289.068822	2.87617188	15.5566406	4.63714355	30.105
3/10/98	0310fwd1.20d	568.740734	547.120039	539.189081	548.797546	576.229689	5067.17712	12.6560713	287.605836	3.25703125	16.9628906	4.63714355	30.105
4/6/98		554.738564	544.781106	534.888117	537.210278	566.947294	3085.1006	11.6723909	100.183806	2.22675781	-16.0839844	4.63714355	29.929
4/6/98	0406fwd1.r01	564.510186	543.143644	540.599375	549.518433	571.185455	5030.36506	13.1911188	282.257946	3.29609375	20.390625	4.63714355	29.929
4/6/98	0406fwd2.r01	564.597506	543.172627	540.972819	549.963109	571.556667	5031.48682	13.1288255	283.388994	3.49140625	21.5332031	4.63714355	29.929
4/6/98	0406fwd3.r01	564.483211	543.136865	540.644594	549.584048	571.250033	5037.662	13.1379684	282.626766	3.77949219	22.9394531	4.63714355	29.929
4/6/98	0406ctr.r01	564.343937	543.044597	540.938392	549.910966	571.614747	5045.66332	13.0507524	283.610286	3.25703125	21.7089844	4.63714355	29.929
4/10/98		549.360648	543.380166	533.837187	534.175812	566.842298	1551.6292	10.9990266	25.743636	1.07929688	-51.7675781	-0.47018066	29.93
4/10/98		556.748186	546.578633	533.7397	536.136819	571.220014	3074.8543	11.4039859	99.187992	2.25117188	1.49414063	4.63714355	29.93
4/10/98	0410fwd1	573.279658	550.647323	539.551173	548.645483	583.876367	5077.93616	13.196107	285.95844	2.42695313	10.6347656	4.63714355	29.93
4/10/98	0410fwd2	574.100007	551.538749	539.699178	548.810327	584.079288	5068.39298	13.2393709	285.269976	2.85175781	10.4589844	4.63714355	29.93
4/10/98	0410fwd3	568.649462	547.67993	539.29123	548.213498	573.249937	5006.83978	13.150341	278.803332	3.08613281	10.1953125	4.63714355	29.93
4/10/98	0410ctr1	566.962962	545.431366	539.906474	548.919189	573.81023	5059.55536	13.1052403	284.888862	2.81269531	12.7441406	4.63714355	29.93
4/10/98	0410ctr2	567.56285	545.929784	541.14	550.150592	574.749882	5062.42906	13.183305	285.552738	2.93476563	13.1835938	4.63714355	29.93
4/10/98	0410ctr3	567.323872	545.80977	540.19531	549.247916	573.967193	5055.83182	13.1090442	286.20432	3.16914063	15.7324219	4.63714355	29.93
5/1/98		560.004017	550.67182	536.030656	538.641051	570.104907	3105.29534	10.6285508	100.097748	0.94746094	-57.9199219	-0.65870605	29.785
5/1/98	0501fwd1	563.855869	542.689482	538.336201	547.649023	571.960393	5008.1299	12.4414992	282.08583	2.27558594	9.40429688	4.63714355	29.79
5/1/98	0501fwd2	567.099619	545.983428	540.001566	549.399399	573.871173	5026.9458	12.409931	281.96289	2.28535156	12.1289063	4.63714355	29.795
5/1/98	0501fwd3	567.797268	546.601326	541.128886	550.541772	574.826145	5028.3132	12.4493037	281.889126	2.55390625	13.6230469	4.63714355	29.797
5/1/98	0501ctr1	570.873909	549.330783	539.633291	549.146081	577.756429	5032.4808	12.36662	281.47113	2.40253906	14.3261719	4.63714355	29.797

Table E.2. TTR Data (2 of 2)

APPENDIX F. COBRA PROBE MEASUREMENTS

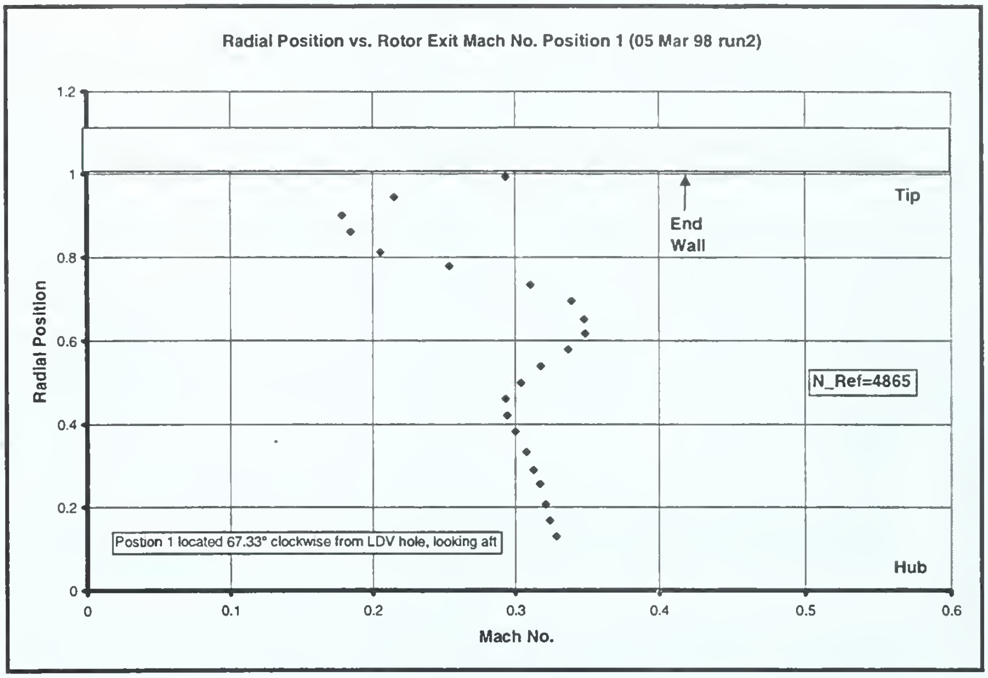

Figure F.1. Cobra Probe Mach Number: Position 1 (05 Mar 98)

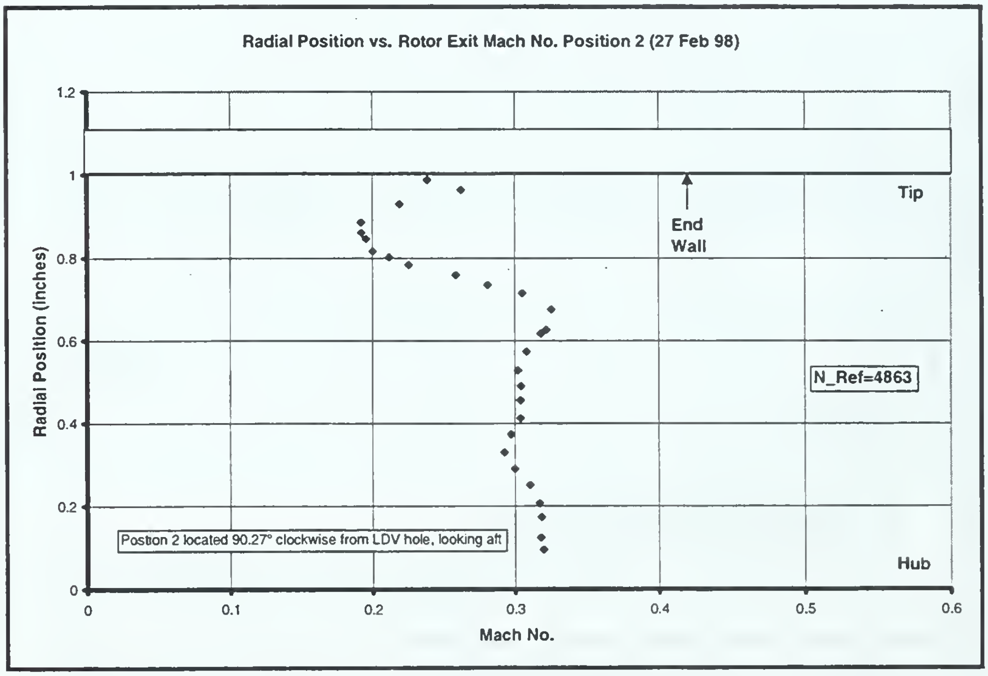

Figure F.2. Cobra Probe Mach Number: Position 2 (27 Feb 98)

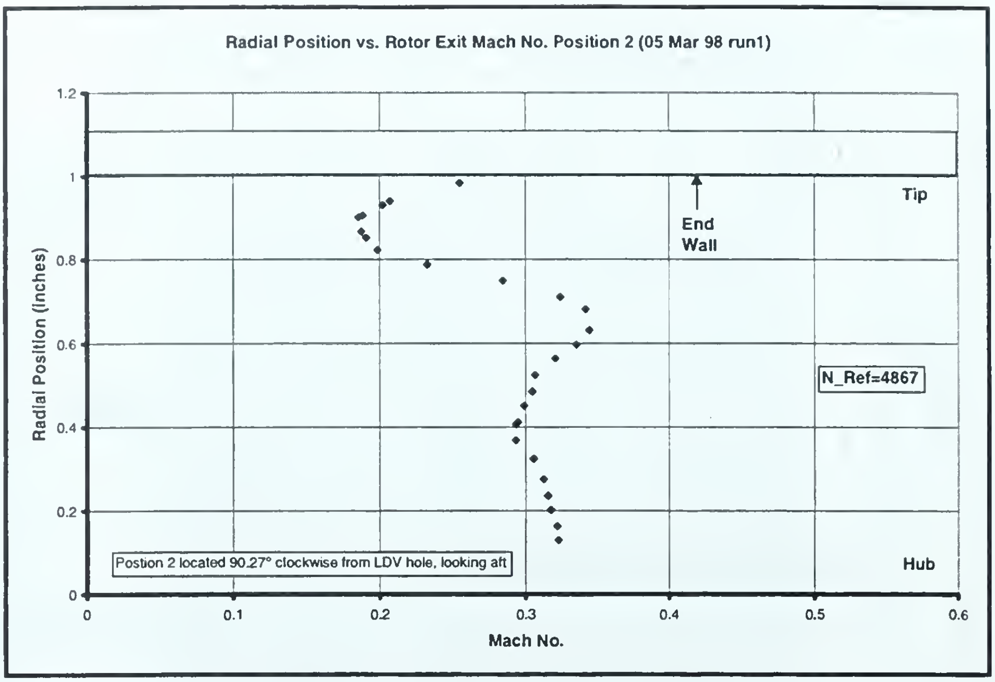

Figure F.3. Cobra Probe Mach Number: Position 2 (05 Mar 98)

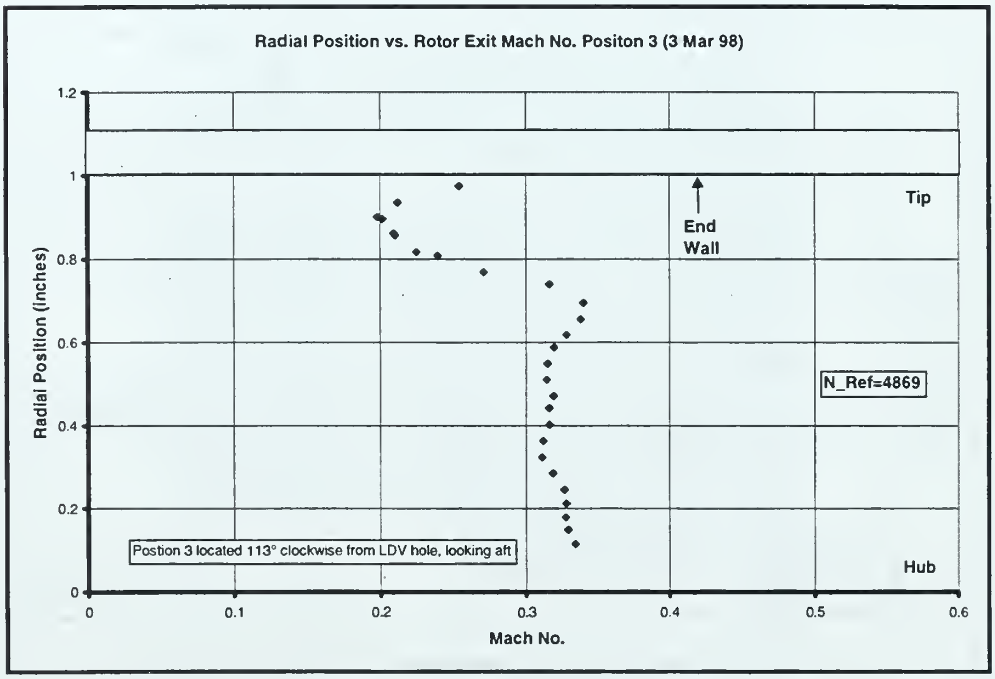

Figure F.4. Cobra Probe Mach Number: Position 3 (03 Mar 98)

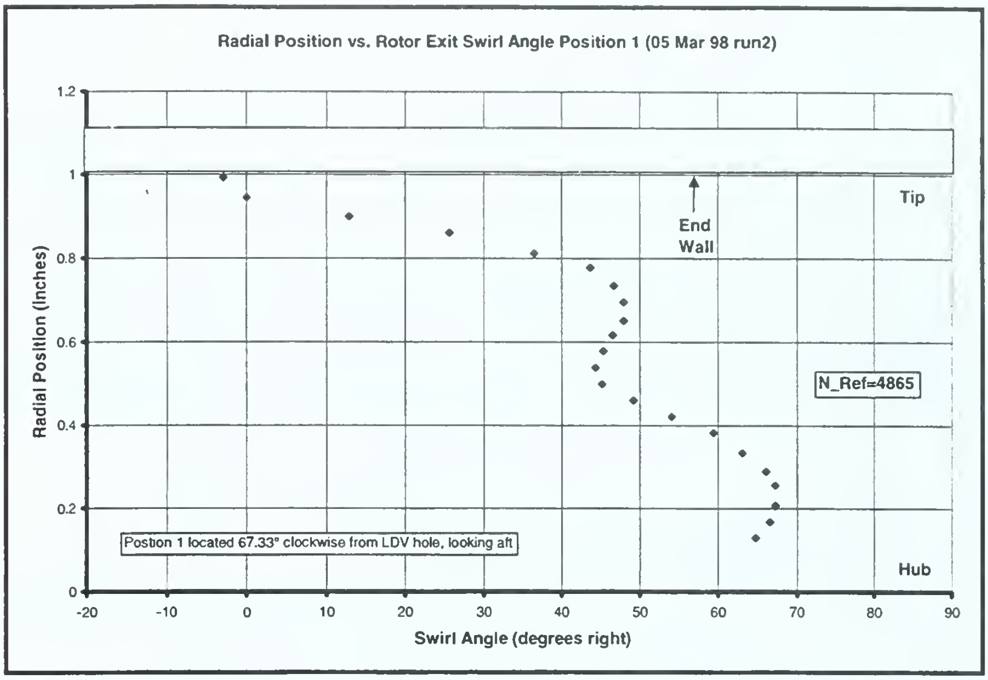

Figure F.5. Cobra Probe Swirl Angle: Position 1 (05 Mar 98)

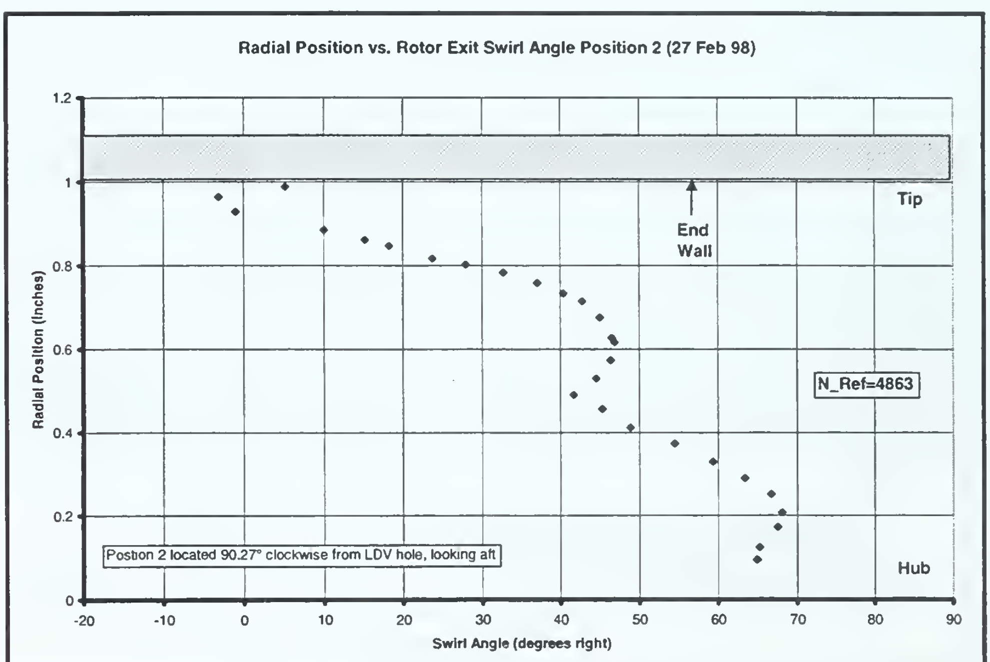

Figure F.6. Cobra Probe Swirl Angle: Position 2 (27 Feb 98)

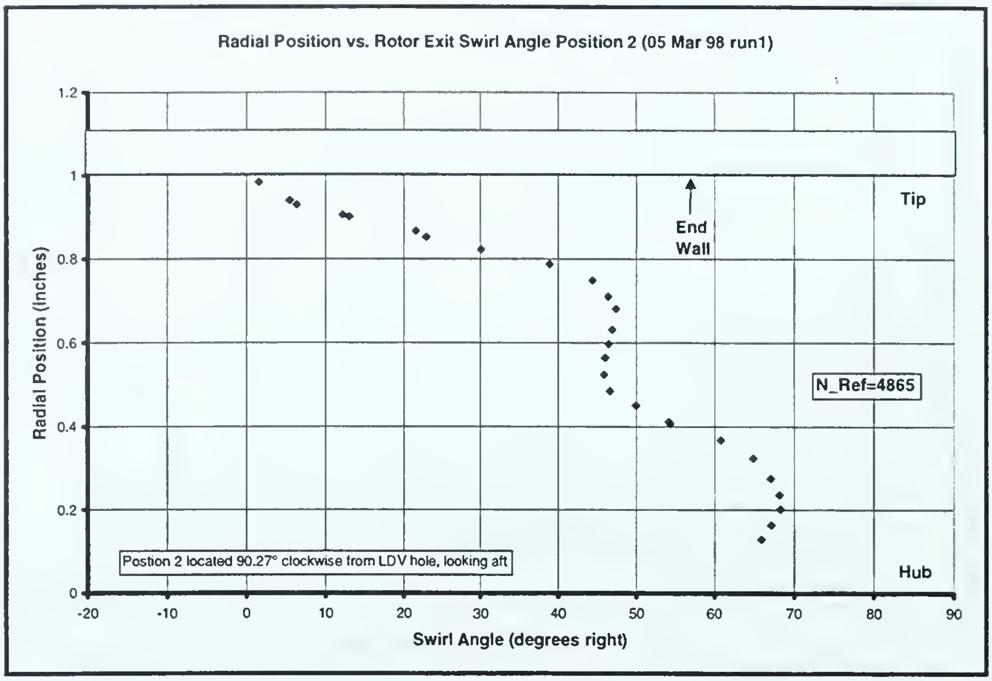

Figure F.7. Cobra Probe Swirl Angle: Position 2 (05 Mar 98)

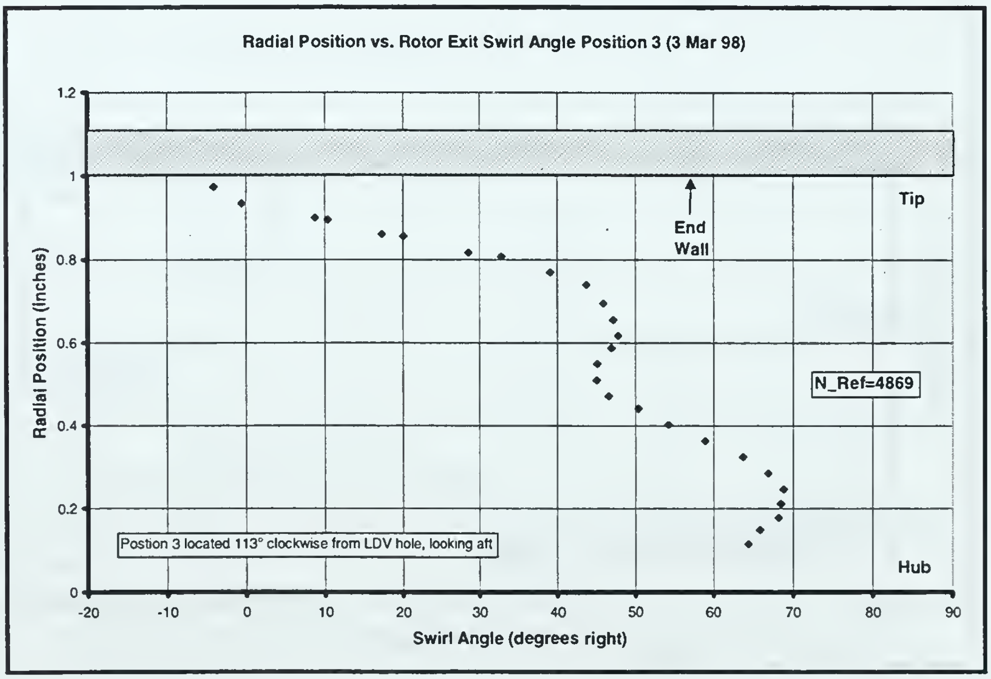

Figure F.8. Cobra Probe Swirl Angle: Position 3 (03 Mar 98)

SSME HPFTP ATD First-Stage Rotor Exit Velocity Survey (Position: 1)

Tar 03/05/98run2	Cal	PT2	Cobra (P1)	Cobra (P23)	ATM Press	Swiral Angle	Radial Pos	RPM	Beta	Dim Vel (X)	Mach # (M)	Prat
-13.5083333	135.324333	117.622	14.314	4.87866667	29.77	7.11914063	1.02234375	5083.10578	0.02179101	0.10800669	0.24293141	0.77488278
-13.597	135.334	117.577333	15.6843333	2.186	29.77	-2.98828125	0.99304688	5095.76702	0.03106986	0.13004374	0.29327708	0.76308291
-13.7456667	135.298667	117.499333	-1.45866667	-8.392	29.77	0	0.94421875	5094.4584	0.01660851	0.09569708	0.21497178	0.75357468
-13.9376667	135.296667	117.139667	-11.4263333	-15.1433333	29.77	12.8320313	0.90027344	5093.65466	0.00911742	0.07950013	0.17833214	0.74356358
-14.0806667	135.357667	117.486	-10.7393333	-15.0036667	29.77	25.5761719	0.86121094	5098.805	0.01043872	0.08212556	0.18426078	0.74328613
-14.3176667	135.292667	115.561333	-4.6	-10.714	29.77	36.4746094	0.81238281	5067.18342	0.01473653	0.09140133	0.20523868	0.75298255
-14.4806667	135.305667	115.445667	4.17366667	-5.85666667	29.77	43.6816406	0.77820313	5065.72158	0.02366627	0.11251958	0.25320944	0.75750656
-14.6786667	135.349667	115.453667	13.6586667	-1.23066667	29.77	46.6699219	0.73425781	5080.03562	0.03434623	0.13746049	0.31031675	0.7575318
-15.013	135.283	115.187	19.3106667	1.69733333	29.77	47.9003906	0.69519531	5071.23684	0.04007645	0.14969492	0.33854263	0.75831455
-15.2443333	135.292333	114.891333	21.448	2.87433333	29.77	47.9003906	0.65125	5078.25542	0.04203499	0.15363627	0.34766885	0.75923444
-15.4143333	135.310333	115.129	20.7946667	2.20833333	29.77	46.4941406	0.61707031	5086.83954	0.04210972	0.15378413	0.34801154	0.75770334
-15.5796667	135.289667	114.617333	18.3856667	0.99433333	29.77	45.3515625	0.57800781	5072.48702	0.03960361	0.14872443	0.33629802	0.75848645
-15.7263333	135.280333	113.886667	15.129	-0.47366667	29.77	44.296875	0.53894531	5066.19702	0.03578388	0.14062369	0.31760009	0.7602812
-15.8563333	135.285333	114.259667	12.917	-1.44733333	29.77	45.1757813	0.49988281	5068.65462	0.03310189	0.13467606	0.30391357	0.76036868
-15.986	135.347	114.174	11.65	-1.753	29.77	49.1308594	0.46082031	5081.59216	0.03096771	0.12980828	0.29273694	0.76179933
-16.1276667	135.282667	114.393667	11.1243333	-2.37133333	29.77	54.0527344	0.42175781	5086.48642	0.0312095	0.13036524	0.29401465	0.76021774
-16.322	135.273	113.890667	11.1186667	-2.86966667	29.77	59.4140625	0.38269531	5074.93686	0.03233472	0.13293909	0.2999229	0.75915324
-16.4993333	135.278333	113.706667	11.4046667	-3.22933333	29.77	63.1054688	0.33386719	5075.44406	0.03379102	0.13622326	0.30747067	0.75758486
-16.666	135.34	113.572667	11.6173333	-3.45	29.77	66.0058594	0.28992188	5081.7052	0.03476117	0.13837952	0.31243184	0.75660237
-16.805	135.283	113.494	11.58	-3.874	29.77	67.2363281	0.25574219	5085.68356	0.03564487	0.14032044	0.31690143	0.75523497
-16.943	135.285	113.584667	11.5706667	-4.227	29.77	67.2363281	0.20691406	5082.95952	0.03642673	0.14201859	0.320815	0.75384479
-17.1323333	135.266333	113.092	11.889	-4.15866667	29.77	66.5332031	0.16785156	5071.38678	0.03695992	0.14316609	0.32346118	0.75427246
-17.2653333	135.273333	112.816	12.8043333	-3.7	29.77	64.7753906	0.12878906	5076.95566	0.03792013	0.14521049	0.32817896	0.75470358

Table F.1. Cobra Probe Data: Position 1 (05 Mar 98)

SSME HPFTP ATD First-Stage Rotor Exit Velocity Survey (Position: 2)

Tar 2/27/98	Cal	PT2	Cobra (P1)	Cobra (P23)	ATM Press	Swiral Angle	Radial Pos	RPM	Beta	Dim Vel (X)	Mach # (M)	Prat
-0.87366667	135.902667	131.213667	26.6313333	15.6113333	30.08	-3.1640625	0.96375	5091.86712	0.02522352	0.11626043	0.26174116	0.76932699
-1.22266667	135.900667	130.427	12.098	4.81166667	30.08	-0.96679688	0.92957031	5073.1986	0.01723721	0.09716387	0.21829792	0.75577988
-1.85766667	135.870667	130.059	1.64066667	-3.32766667	30.08	10.0195313	0.885625	5081.24696	0.01203315	0.08545021	0.1917739	0.74344587
-2.20366667	135.857667	129.759667	0.90566667	-4.361	30.08	18.28125	0.8465625	5095.89802	0.01276773	0.08703199	0.1953507	0.74196725
-2.51566667	135.858667	129.637667	7.631	0.929	30.08	27.8613281	0.80261719	5084.18192	0.01597481	0.09422996	0.21164632	0.75089527
-3.49633333	135.816333	128.774667	17.2643333	6.685	30.08	37.0019531	0.75867188	5099.86464	0.02459455	0.11475119	0.25829772	0.75813111
-3.86966667	135.817667	128.539667	26.7036667	12.048	30.08	42.8027344	0.71472656	5099.27474	0.0333112	0.13514733	0.30499681	0.76130391
-4.23966667	135.817667	127.808333	30.429	13.896	30.08	44.9121094	0.67566406	5087.3482	0.03723167	0.14374757	0.32480261	0.76234826
-4.802	135.815	127.396	29.605	13.366	30.08	46.4941406	0.62683594	5099.43264	0.03659115	0.14237337	0.321633	0.76275887
-5.19233333	135.786333	127.1	28.73	12.8416667	30.08	46.8457031	0.61707031	5094.9267	0.03584014	0.14074626	0.31788251	0.76304759
-5.51033333	135.776333	126.825333	26.2176667	11.2693333	30.08	46.3183594	0.573125	5096.00538	0.03388747	0.13643881	0.3079664	0.76245155
-5.85566667	135.813667	126.968	24.784	10.3706667	30.08	44.5605469	0.52917969	5101.3642	0.03275546	0.13389356	0.30211543	0.76175221
-6.34266667	135.762667	125.945667	24.0493333	9.48966667	30.08	41.6601563	0.49011719	5096.79814	0.03310664	0.13468678	0.30393822	0.76149741
-6.86866667	135.773667	126.248333	23.629	9.085	30.08	45.2636719	0.4559375	5103.04602	0.03306308	0.13458855	0.30371245	0.76058864
-7.13166667	135.756667	125.033333	22.5143333	8.00133333	30.08	48.8671875	0.41199219	5101.55558	0.03305661	0.13457395	0.30367891	0.76046116
-7.824	135.74	124.829333	20.8266667	6.912	30.08	54.4921875	0.37292969	5095.50692	0.03176578	0.13164148	0.29694347	0.76016513
-8.21633333	135.726333	124.64	19.7076667	6.19166667	30.08	59.3261719	0.32898438	5106.47568	0.03090694	0.12966809	0.2924154	0.76001421
-8.56366667	135.726667	124.202	19.8946667	5.75233333	30.08	63.3691406	0.28992188	5104.37434	0.03229971	0.13285947	0.29974004	0.7588026
-8.922	135.707	123.716333	20.6176667	5.54933333	30.08	66.6210938	0.25085938	5105.73712	0.03432982	0.13742403	0.31023286	0.75751609
-9.35466667	135.723667	123.378667	20.918	5.24733333	30.08	68.0273438	0.20691406	5109.26694	0.03564257	0.14031544	0.3168899	0.756477
-9.60833333	135.693333	122.864667	20.7806667	5.035	30.08	67.5	0.17273438	5094.42762	0.03580369	0.14066686	0.31769955	0.75677385
-10.022	135.727	122.505333	20.545	4.807	30.08	65.2148438	0.12390625	5110.6022	0.03577178	0.14059731	0.31753931	0.75705712
-11.8183333	135.695333	120.594	19.0943333	3.19166667	30.08	64.8632813	0.09460938	5097.76176	0.03611768	0.14134953	0.31927274	0.75723903
-12.4473333	135.623333	119.819667	15.5563333	6.41433333	30.08	5.18554688	0.98816406	5110.87922	0.02090114	0.10586861	0.23806731	0.77627385
-12.6523333	135.640333	119.267667	-14.4503333	-12.4686667	30.08	-13.2714844	1.03210938	5099.18338	-0.0048619	0.06431108	0.14410226	0.74212922
-12.9703333	135.650333	119.446667	-10.6063333	-15.5913333	30.08	15.1171875	0.86121094	5100.47522	0.01210678	0.08560742	0.19212933	0.7406485
-13.2856667	135.604667	118.761	-7.133	-12.8436667	30.08	23.7304688	0.81726563	5098.643	0.01374271	0.08917389	0.20019644	0.74633206
-13.469	135.652	119.093667	0.927	-6.90166667	30.08	32.6074219	0.78308594	5105.9087	0.01847321	0.10007506	0.22490368	0.75489249
-13.628	135.608	118.467333	12.0933333	-0.35666667	30.08	40.3417969	0.73425781	5097.35864	0.02861345	0.12432118	0.28016413	0.76091613

Table F.2. Cobra Probe Data: Position 2 (27 Feb 98)

SSME HPFTP ATD First-Stage Rotor Exit Velocity Survey (Position: 2)

Tar 3/5/1998run1	Cal	PT2	Cobra (P1)	Cobra (P23)	ATM Press	Swiral Angle	Radial Pos	RPM	Beta	Dim Vel (X)	Mach # (M)	Prat
-4.789	135.558	125.732333	24.6833333	15.312	29.765	5.9765625	1.01257813	5059.3154	0.02156441	0.10746184	0.24169155	0.77902069
-5.464	135.568	125.971667	18.28	8.00133333	29.765	1.49414063	0.98328125	5091.66108	0.02396822	0.11324589	0.25486506	0.76397855
-6.78633333	135.546333	123.227	3.521	-2.72533333	29.765	5.36132813	0.93933594	5053.43842	0.01503659	0.09208169	0.20677943	0.75350376
-8.013	135.539	122.684	-5.47566667	-10.083	29.765	12.1289063	0.90515625	5084.4813	0.01130248	0.0839071	0.18828595	0.74222336
-9.14066667	135.531667	121.344667	-6.66433333	-11.1656667	29.765	21.5332031	0.86609375	5074.92748	0.0110441	0.08336915	0.18707032	0.74264109
-9.65733333	135.523333	121.504333	-2.25733333	-7.768	29.765	30.0585938	0.82214844	5081.5961	0.01335914	0.08832577	0.19827737	0.74841532
-10.6623333	135.527333	119.668667	4.90333333	-3.44566667	29.765	38.8476563	0.78796875	5072.62446	0.01984704	0.10334406	0.2323283	0.75668076
-11.7093333	135.506333	119.165333	12.9423333	0.33433333	29.765	44.296875	0.74890625	5082.0204	0.02933776	0.12602098	0.28405609	0.75812331
-12.401	135.506	117.970333	19.247	3.05666667	29.765	46.3183594	0.70984375	5067.04526	0.03707005	0.14340202	0.32400543	0.75842214
-13.171	135.49	117.319	22.351	4.413	29.765	47.3730469	0.68054688	5093.2534	0.04071048	0.15098474	0.34152738	0.75889505
-13.664	135.498	116.884333	22.2273333	4.01733333	29.765	46.8457031	0.63171875	5073.9534	0.04129317	0.15215842	0.34424492	0.75848111
-14.237	135.467	116.401333	19.871	2.57433333	29.765	46.40625	0.59753906	5086.03586	0.03938134	0.14826572	0.33523742	0.75845646
-14.6566667	135.531667	116.274333	17.1693333	1.283	29.765	45.8789063	0.56335938	5086.25338	0.03635919	0.14187261	0.32047846	0.75912144
-15.2263333	135.462333	115.564333	14.476	-0.13333333	29.765	45.7910156	0.52429688	5069.24266	0.03359981	0.13579526	0.30648643	0.76019397
-15.6563333	135.484333	115.354333	13.1523333	-1.252	29.765	46.5820313	0.48523438	5086.6023	0.03319657	0.13488938	0.30440387	0.75898345
-15.889	135.472	114.630667	12.041	-1.87666667	29.765	49.921875	0.45105469	5081.54368	0.03214007	0.13249603	0.29890542	0.75987183
-16.1843333	135.455333	114.450667	10.7516667	-2.65366667	29.765	54.3164063	0.40710938	5096.72056	0.03102816	0.12994765	0.29305665	0.75977188
-16.9403333	135.430333	113.481667	9.91533333	-3.59	29.765	54.140625	0.41199219	5072.80316	0.03126543	0.13049388	0.29430981	0.75954793
-17.1373333	135.432333	113.235	9.626	-3.769	29.765	60.8203125	0.36804688	5078.61438	0.03101664	0.12992109	0.29299573	0.75985944
-17.4173333	135.441333	112.944333	10.3346667	-4.12033333	29.765	64.8632813	0.32410156	5078.58372	0.03339466	0.13533492	0.30542805	0.75772753
-17.6056667	135.431667	112.345	10.6193333	-4.43766667	29.765	67.0605469	0.27527344	5070.93662	0.03474746	0.13834924	0.31236213	0.75690773
-17.7516667	135.432667	111.553333	10.4583333	-4.85233333	29.765	68.1152344	0.23621094	5077.04222	0.03533408	0.13964041	0.31533501	0.75682587
-17.9466667	135.438667	112.346	10.5706667	-4.91933333	29.765	68.2910156	0.20203125	5069.56464	0.03572261	0.1404901	0.31729229	0.7553234
-18.1003333	135.417333	111.924333	10.8843333	-5.00433333	29.765	67.1484375	0.16296875	5075.8252	0.03660255	0.14239794	0.32168964	0.75505934
-18.2856667	135.458667	112.104667	11.5496667	-4.45866667	29.765	65.9179688	0.12878906	5068.99806	0.0368061	0.14283593	0.32269968	0.75568503
-18.5786667	135.395667	111.608333	-15.2826667	-20.0933333	29.765	22.8515625	0.85144531	5068.11198	0.01177937	0.08491069	0.19055424	0.74386881
-18.7416667	135.427667	111.252333	-16.4003333	-20.7233333	29.765	13.0078125	0.90027344	5075.49472	0.01061007	0.0824751	0.18505037	0.74346518
-18.8593333	135.394333	111.561333	-9.18233333	-15.0286667	29.765	6.24023438	0.92957031	5066.53114	0.01409507	0.08995884	0.20197297	0.75281418

Table F.3. Cobra Probe Data: Position 2 (05 Mar 98)

SSME HPFTP ATD First-Stage Rotor Exit Velocity Survey (Position: 3)

Tar 3/3/98	Cal	PT2	Cobra (P1)	Cobra (P23)	ATM Press	Swiral Angle	Radial Pos	RPM	Beta	Dim Vel (X)	Mach # (M)	Prat
-0.728	135.955	130.807333	22.91566667	12.62933333	29.975	-4.13085938	0.97351563	5084.32692	0.02383284	0.11292028	0.25412278	0.76487569
-1.666	135.976	129.416667	7.510666667	0.829	29.975	-0.61523438	0.93445313	5084.37554	0.01601794	0.09432942	0.21187173	0.75001395
-2.43666667	135.955667	129.372333	0.076	-5.36566667	29.975	8.701171875	0.90027344	5089.4884	0.01325708	0.08810129	0.19776948	0.74000045
-3.07133333	135.934333	128.349333	0.385666667	-5.99166667	29.975	17.31445313	0.86121094	5091.79456	0.01550091	0.09314106	0.20917906	0.73984817
-3.74233333	135.963333	127.444667	6.214666667	-1.51033333	29.975	28.56445313	0.81726563	5090.5295	0.01848454	0.1001019	0.2249646	0.74829813
-4.57966667	135.935667	127.075333	15.87533333	4.366666667	29.975	39.0234375	0.7684375	5093.2552	0.02686338	0.12017837	0.27068888	0.75451341
-5.324	135.952	125.952	23.611	8.122	29.975	43.59375	0.73914063	5095.5214	0.03545248	0.13989981	0.31593247	0.75605465
-6.11166667	135.937667	125.51	27.75533333	9.923666667	29.975	45.79101563	0.69519531	5101.54174	0.04035896	0.15027126	0.33987612	0.75592209
-6.54266667	135.933667	125.148	27.58066667	9.922666667	29.975	47.109375	0.65613281	5094.25062	0.03994272	0.14942118	0.33790941	0.75695409
-7.49933333	135.955333	123.188667	25.101	8.391333333	29.975	47.72460938	0.61707031	5085.97334	0.03792824	0.14522762	0.32821852	0.75909883
-8.03866667	135.916667	122.513333	22.94366667	7.096	29.975	46.84570313	0.58777344	5082.58882	0.03610423	0.14132036	0.3192055	0.75953466
-8.48633333	135.935333	121.964667	21.71766667	6.289666667	29.975	45	0.54871094	5076.5553	0.03521058	0.13936941	0.31471092	0.75981417
-8.886	135.98	121.862	21.34966667	5.939	29.975	44.91210938	0.50964844	5080.79188	0.03516848	0.13927693	0.31449794	0.75952001
-9.34866667	135.912667	121.08	20.69566667	4.917666667	29.975	46.49414063	0.47058594	5068.11598	0.0360225	0.1411429	0.31879651	0.7582209
-9.77133333	135.921333	120.728	19.766	4.275	29.975	50.36132813	0.44128906	5081.59294	0.03540824	0.13980293	0.31570934	0.75826236
-10.124	135.999	120.760667	18.615	3.114333333	29.975	54.22851563	0.40222656	5078.9642	0.0354951	0.1399931	0.31614735	0.75619381
-10.415	135.929	120.284667	17.52933333	2.430666667	29.975	58.88671875	0.36316406	5076.25462	0.03463759	0.13810632	0.311803	0.75649235
-10.7413333	135.913333	119.632667	16.98433333	1.981	29.975	63.72070313	0.32410156	5076.65522	0.03443616	0.13766008	0.31077603	0.75690252
-10.9806667	135.918667	119.642333	17.46066667	1.781666667	29.975	66.88476563	0.28503906	5078.62588	0.03592796	0.1409374	0.31832294	0.75532974
-11.2526667	135.929667	119.692333	17.768	1.346	29.975	68.81835938	0.24597656	5069.89868	0.03758063	0.14449094	0.32651799	0.75314634
-11.5173333	135.907333	119.101667	17.711	1.160333333	29.975	68.46679688	0.21179688	5074.2438	0.03785709	0.14507714	0.32787111	0.75350296
-11.831	135.916	119.223667	17.52033333	1.004333333	29.975	68.203125	0.17761719	5085.74354	0.03776717	0.14488673	0.32743156	0.75325442
-12.168	135.918	118.514333	17.69	1.021333333	29.975	65.83007813	0.14832031	5077.51688	0.03807216	0.14553153	0.32892021	0.75414333
-12.5116667	135.906667	118.267667	18.18466667	1.017	29.975	64.42382813	0.11414063	5073.32418	0.03913696	0.14775952	0.33406727	0.75368764
-12.8626667	135.922667	117.818	0.740333333	-8.154	29.975	32.78320313	0.8075	5072.07914	0.02109848	0.10634234	0.23914475	0.75210036
-13.1556667	135.897667	117.654	-8.48966667	-14.9523333	29.975	20.0390625	0.85632813	5085.60934	0.0156623	0.09351104	0.21001729	0.7426827
-13.433	135.859	116.959	-11.264	-17.0006667	29.975	10.37109375	0.89539063	5080.71352	0.01398748	0.08971858	0.20142917	0.74057527

Table F.4. Cobra Probe Data: Position 3 (03 Mar 98)

APPENDIX G. LDV MEASUREMENT DATA

First Stage Rotor LDV Data				Window Ave: On						
Date:03/10/98				Axial Pos: -.16ct						
N_Ref: 4862				Span Pos: 88%						
Vt= 794				t: .020 in						
Filter Setting: 5-30MHz				no freq shifting						
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial	
0	79.93	88.69	24.47	8.91	42.026	47.974	-0.0729	0.100668	0.1117	
0.1	89.05	81.11	20.46	14.88	47.669	42.331	0.04201	0.112154	0.102154	
0.2	90.82	80.51	20.03	14.3	48.443	41.557	0.01016	0.114383	0.101398	
0.3	90.31	79.82	20.27	14.81	48.53	41.47	-0.04443	0.113741	0.100529	
0.4	90.56	80.11	19.97	14.76	48.505	41.495	-0.01946	0.114055	0.100894	
0.5	92.78	80.11	20.21	14.17	49.193	40.807	-0.03148	0.116851	0.100894	
0.6	91.85	78.67	21.05	15.49	49.422	40.578	0.0834	0.11568	0.099081	
0.7	89.28	80.28	21.82	14.6	48.038	41.962	-0.13848	0.112443	0.101108	
0.8	91.43	79.71	22.05	15.16	48.916	41.084	-0.06979	0.115151	0.10039	
0.9	89.92	80.3	21.84	14.24	48.233	41.767	0.03845	0.113249	0.101134	
1	89.78	79.48	20.51	15.16	48.482	41.518	-0.0241	0.113073	0.100101	
1.1	89.23	79.93	22.11	13.86	48.144	41.856	0.07521	0.11238	0.100668	
1.2	92.02	80.12	22.05	14.07	48.955	41.045	0.05385	0.115894	0.100907	
1.3	89.6	80.14	22.65	14.21	48.193	41.807	-0.02381	0.112846	0.100932	
1.4	90.24	80.13	20.92	13.75	48.394	41.606	-0.07462	0.113652	0.100919	
1.5	87.96	79.84	22.94	14.79	47.769	42.231	-0.10405	0.110781	0.100554	
1.6	89.47	79.33	21.47	15.11	48.437	41.563	-0.00006	0.112683	0.099912	
1.7	89.68	80.26	21.58	13.35	48.174	41.826	-0.0339	0.112947	0.101083	
1.8	88.55	79.78	22.97	14.37	47.983	42.017	-0.05604	0.111524	0.100479	
1.9	90.57	78.56	22.68	14.31	49.061	40.939	-0.03502	0.114068	0.098942	
2	89.53	80.93	21.13	14.56	47.888	42.112	0.06588	0.112758	0.101927	
2.1	89.98	79.23	21.37	14.95	48.634	41.366	0.03119	0.113325	0.099786	
2.2	88.62	79.67	21.92	14.91	48.045	41.955	0.0868	0.111612	0.10034	
2.3	87.18	81.79	22	13.9	46.83	43.17	-0.05121	0.109798	0.10301	
2.4	87.15	79.28	22.99	15.92	47.708	42.292	0.10982	0.109761	0.099849	
2.5	85.62	79.28	22.37	14.44	47.201	42.799	-0.01599	0.107834	0.099849	
2.6	86.3	80.58	21.37	13.27	46.961	43.039	0.03614	0.10869	0.101486	
2.7	86.3	81.13	21.88	14.72	46.771	43.229	-0.06853	0.10869	0.102179	
2.8	85.24	80.38	21.31	13.74	46.682	43.318	0.01004	0.107355	0.101234	
2.9	83.64	80.25	21.06	13.66	46.184	43.816	0.08305	0.10534	0.101071	
3	86.44	80.76	21.37	13.84	46.944	43.056	0.03881	0.108866	0.101713	
3.1	86.69	79.87	21.44	14.68	47.344	42.656	0.06961	0.109181	0.100592	
3.2	83.95	81.18	22.5	14.19	45.958	44.042	0.00572	0.10573	0.102242	
3.3	85.57	80.92	21.63	13.86	46.603	43.397	0.00966	0.107771	0.101914	
3.4	86.06	80.09	19.63	14.4	47.055	42.945	0.00241	0.108388	0.100869	
3.5	84.46	78.46	21.37	15.25	47.11	42.89	-0.03388	0.106373	0.098816	
3.6	84.75	79.39	21.5	16.44	46.87	43.13	0.01981	0.106738	0.099987	
3.7	85.29	80.83	20.09	14.41	46.538	43.462	0.01361	0.107418	0.101801	
3.8	85.26	81.58	22.65	13.6	46.262	43.738	-0.00462	0.10738	0.102746	
3.9	84.71	80.4	21.24	15.88	46.496	43.504	0.11811	0.106688	0.101259	
4	85.21	79.29	18.97	14.94	47.059	42.941	-0.00059	0.107317	0.099861	
4.1	84.66	79.64	19.22	15.52	46.748	43.252	0.05123	0.106625	0.100302	
4.2	87.95	79.64	19.6	14.85	47.841	42.159	-0.02916	0.110768	0.100302	
4.3	84.24	80.63	19.35	13.73	46.255	43.745	0.10673	0.106096	0.101549	
4.4	84.45	81	19.79	14.72	46.193	43.807	-0.04682	0.10636	0.102015	
4.5	84.53	78.77	20.4	15.06	47.02	42.98	0.00158	0.106461	0.099207	
4.6	84.39	79.84	19.59	15.02	46.589	43.411	-0.11108	0.106285	0.100554	
4.7	86.73	81.51	19.65	13.21	46.776	43.224	0.08357	0.109232	0.102657	
4.8	86.69	81.01	20.84	14.74	46.94	43.06	-0.04582	0.109181	0.102028	
4.9	88.06	80.4	18.94	14.1	47.604	42.396	0.01081	0.110907	0.101259	
5	86.73	79.57	19.45	13.86	47.466	42.534	-0.05668	0.109232	0.100214	
5.1	88.29	80.86	20.02	13.33	47.515	42.485	0.01695	0.111196	0.101839	
5.2	87.59	80.48	19.45	14	47.424	42.576	0.02994	0.110315	0.10136	
5.3	84.99	79.41	19.01	15.3	46.941	43.059	0.02827	0.10704	0.100013	
5.4	89.54	80.2	19.22	14.36	48.151	41.849	0.03113	0.112771	0.101008	
5.5	88.85	80.7	20.02	14.12	47.752	42.248	-0.03987	0.111902	0.101637	
5.6	88.61	80.48	18.79	13.95	47.753	42.247	-0.0811	0.111599	0.10136	
5.7	88.71	81.01	20.93	14.93	47.598	42.402	0.03016	0.111725	0.102028	
5.8	86.18	80.82	19.21	14.24	46.84	43.16	0.01686	0.108539	0.101788	
5.9	87.37	80.83	19.51	13.6	47.227	42.773	-0.01293	0.110038	0.101801	
6	87.7	80.83	19.86	13.29	47.334	42.666	-0.02809	0.110453	0.101801	
6.1	89.19	81.3	20.3	13.17	47.649	42.351	-0.07995	0.11233	0.102393	
6.2	87.71	81.13	20.23	14.22	47.232	42.768	0.04817	0.110466	0.102179	
6.3	89.58	81.65	20.07	13.85	47.649	42.351	-0.00508	0.112821	0.102834	
6.4	89.53	81.13	19.49	14	47.818	42.182	0.0395	0.112758	0.102179	
6.5	89	81.16	20.3	13.48	47.637	42.363	0.01148	0.112091	0.102217	
6.6	89.69	79.75	20.3	14.23	48.36	41.64	0.06607	0.11296	0.100441	
6.7	91.33	82.63	19.03	13.19	47.863	42.137	0.02975	0.115025	0.104068	

Table G.1. LDV Data: Forward Position, Inner Depth (10 Mar 98)

First Stage Rotor LDV Data				Window Ave: on					
Date: 03/10/98				Axial Pos: -0.16ct					
N_Ref: 4839				Span Pos: 93					
Vt= 795				t: .020 in					
Filter Setting: 5-30MHz				no freq shifting					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
0	83.39	85.06	32.64	13.88	44.433	45.567	-0.38422	0.104893	0.106994
0.1	91.65	80.07	20.72	14.4	48.859	41.141	-0.09858	0.115283	0.100717
0.2	91.73	79.76	20.97	15.55	48.992	41.008	-0.06096	0.115384	0.100327
0.3	92.2	80.05	18.88	14.3	49.036	40.964	0.0679	0.115975	0.100692
0.4	92.68	79.88	19.68	14.28	49.243	40.757	0.02446	0.116579	0.100478
0.5	92.33	79.59	20.18	14	49.237	40.763	-0.09864	0.116138	0.100113
0.6	92.42	79.56	19.93	14.65	49.278	40.722	-0.02862	0.116252	0.100075
0.7	93	78.74	20.27	15.09	49.747	40.253	-0.04118	0.116981	0.099044
0.8	91.86	78.82	20.3	14.56	49.366	40.634	-0.04776	0.115547	0.099145
0.9	92.68	79.55	20.68	15.02	49.361	40.639	-0.12003	0.116579	0.100063
1	91.47	79.02	19.81	14.56	49.176	40.824	-0.07987	0.115057	0.099396
1.1	92.86	78.85	21.33	15.15	49.665	40.335	-0.07996	0.116805	0.099182
1.2	89.94	79.21	21.59	14.14	48.63	41.37	-0.10503	0.113132	0.099635
1.3	91	79.67	20.86	14.48	48.799	41.201	-0.09713	0.114465	0.100214
1.4	90.57	78.83	21.49	14.43	48.962	41.038	-0.0659	0.113925	0.099157
1.5	91.42	80.02	21.97	13.87	48.802	41.198	-0.07133	0.114994	0.100654
1.6	91.14	78.97	21.39	14.59	49.089	40.911	-0.01969	0.114642	0.099333
1.7	89.05	79.1	22.64	13.96	48.385	41.615	0.01574	0.112013	0.099497
1.8	89.53	78.68	22.53	15.02	48.689	41.311	-0.15607	0.112616	0.098969
1.9	90.92	79.5	21.45	14.62	48.833	41.167	-0.11002	0.114365	0.1
2	88.41	81.13	20.77	13.45	47.457	42.543	-0.04403	0.111208	0.10205
2.1	88.89	78.51	20.98	15.68	48.548	41.452	-0.03756	0.111811	0.098755
2.2	87.79	79.8	22.65	15.45	47.729	42.271	0.0029	0.110428	0.100377
2.3	91.5	80.47	22.33	13.79	48.67	41.33	-0.1094	0.115094	0.10122
2.4	86.88	79.72	22.4	14.73	47.461	42.539	0.00279	0.109283	0.100277
2.5	89.87	81.08	22.5	12.65	47.941	42.059	-0.0448	0.113044	0.101987
2.6	89.13	80.81	20.76	13.86	47.805	42.195	0.08061	0.112113	0.101648
2.7	87.78	79.49	21.22	14.6	47.837	42.163	0.09444	0.110415	0.099987
2.8	88.86	77.99	21.03	16.33	48.728	41.272	0.13849	0.111774	0.098101
2.9	88.23	81.54	23.25	12.49	47.257	42.743	0.02513	0.110981	0.102566
3	86.85	80.35	22.15	14.49	47.229	42.771	0.00981	0.109245	0.101069
3.1	89.66	80.86	19.87	13.31	47.956	42.044	0.03376	0.11278	0.101711
3.2	84.21	80.38	20.53	15.28	46.332	43.668	0.05512	0.105925	0.101107
3.3	84.84	80.56	22.09	15.18	46.483	43.517	0.04205	0.106717	0.101333
3.4	86.23	81.51	20.74	13.88	46.611	43.389	0.0167	0.108465	0.102528
3.5	88.89	80.09	19.65	14.69	47.98	42.02	-0.05431	0.111811	0.100742
3.6	85.82	79.55	20.91	14.2	47.171	42.829	-0.11759	0.10795	0.100063
3.7	87.77	79.63	19.72	14.73	47.783	42.217	-0.03774	0.110403	0.100164
3.8	87.19	80.7	19.47	14.04	47.211	42.789	-0.09956	0.109673	0.101509
3.9	87.69	81.71	19.49	13.75	47.02	42.98	0.00357	0.110302	0.10278
4	89.72	81.7	19.83	14.31	47.679	42.321	0.02938	0.112855	0.102767
4.1	85.27	79.3	19.05	15.56	47.077	42.923	-0.04626	0.107258	0.099748
4.2	86.96	80.62	19.5	13.88	47.167	42.833	0.03721	0.109384	0.101409
4.3	87.71	80.83	17.7	13.84	47.337	42.663	-0.00291	0.110327	0.101673
4.4	86.71	81.28	20.17	13.48	46.85	43.15	0.03409	0.109069	0.102239
4.5	86.67	79.57	20.43	15.33	47.446	42.554	-0.021	0.109019	0.100088
4.6	86.28	80.11	20.34	14.34	47.121	42.879	0.03325	0.108528	0.100767
4.7	87.15	81.5	20.9	13.86	46.918	43.082	0.05721	0.109623	0.102516
4.8	89.34	81.1	18.72	14	47.769	42.231	0.04213	0.112377	0.102013
4.9	88.21	80.27	19.38	15.49	47.697	42.303	0.03398	0.110956	0.100969
5	88.44	79.73	20.7	15.12	47.966	42.034	-0.03824	0.111245	0.100289
5.1	89.23	80.88	18.52	14.72	47.812	42.188	-0.0521	0.112239	0.101736
5.2	90.1	79.53	17.92	14.88	48.567	41.433	-0.00144	0.113333	0.100038
5.3	89.65	79.81	18.98	14.77	48.325	41.675	-0.00569	0.112767	0.10039
5.4	89.37	80.76	19.28	13.93	47.897	42.103	0.01003	0.112415	0.101585
5.5	90.19	79.95	18.06	15.35	48.446	41.554	0.01561	0.113447	0.100566
5.6	89.33	81.01	19.56	14.22	47.797	42.203	0.03146	0.112365	0.101899
5.7	88.51	80.66	20.36	14.23	47.657	42.343	0.04305	0.111333	0.101459
5.8	92.23	81.64	19.27	14.56	48.486	41.514	0.01549	0.116013	0.102692
5.9	90.71	80.19	18.41	14.88	48.522	41.478	0.03785	0.114101	0.100868
6	88.88	81.64	18.48	13.71	47.429	42.571	-0.07013	0.111799	0.102692
6.1	89.86	80	20.72	14.9	48.319	41.681	-0.15646	0.113031	0.100629
6.2	90.74	81.58	18.28	14.17	48.044	41.956	0.00939	0.114138	0.102616
6.3	90.39	81.56	19.98	13.52	47.938	42.062	-0.02314	0.113698	0.102591
6.4	89.94	81.03	18.37	14.2	47.987	42.013	-0.00241	0.113132	0.101925
6.5	91.59	80.2	19.38	14.74	48.792	41.208	-0.00004	0.115208	0.100881
6.6	91.94	79.28	19.72	14.35	49.229	40.771	0.0079	0.115648	0.099723
6.7	90.85	79.49	18.94	14.66	48.816	41.184	-0.0434	0.114277	0.099987

Table G.2. LDV Data: Forward Position, Middle Depth (10 Mar 98)

First-Stage Rotor LDV Data				Window Av on					
Date: 03/10/98				Axial Pos: -0.16ct					
N_Ref: 4839				Span Pos: 98					
Vt:	795			t: .020 in					
Filter Settings: 5-30MHz				no freq shifting					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
0	99.86	74.64	15.92	20.98	53.226	36.774	-0.17379	0.12561	0.093887
0.1	91.51	79.12	19.43	14.8	49.154	40.846	-0.12735	0.115107	0.099522
0.2	92.59	79.25	18.24	16.43	49.439	40.561	0.01177	0.116465	0.099686
0.3	90.1	77.69	20.07	16	49.229	40.771	-0.109	0.113333	0.097723
0.4	90.73	78.02	18.67	16.75	49.309	40.691	0.01372	0.114126	0.098138
0.5	92.35	78.89	20.65	15.95	49.493	40.507	-0.10544	0.116164	0.099233
0.6	89.54	79.56	20.84	14.51	48.378	41.622	-0.08813	0.112629	0.100075
0.7	89.68	79.36	19.77	14.73	48.492	41.508	0.01627	0.112805	0.099824
0.8	90.33	78.54	19.87	16.55	48.993	41.007	-0.03326	0.113623	0.098792
0.9	89.85	79.08	20.29	15.14	48.649	41.351	-0.04758	0.113019	0.099472
1	89.64	77.47	19.36	16.39	49.164	40.836	-0.17123	0.112755	0.097447
1.1	91.64	77.82	20	16.91	49.661	40.339	-0.04082	0.11527	0.097887
1.2	90.55	78.7	19.65	15.11	49.005	40.995	-0.02338	0.113899	0.098994
1.3	91.35	78.18	20.33	15.77	49.445	40.555	-0.06355	0.114906	0.09834
1.4	90.19	78.91	19.9	15.97	48.817	41.183	-0.04026	0.113447	0.099258
1.5	90.14	77.73	19.6	16.98	49.229	40.771	-0.18105	0.113384	0.097774
1.6	90.42	78.65	20.65	16.5	48.983	41.017	-0.0664	0.113736	0.098931
1.7	92.81	77.74	18.7	16.31	50.051	39.949	-0.09683	0.116742	0.097786
1.8	90.89	77.57	19.72	16.79	49.523	40.477	-0.18659	0.114327	0.097572
1.9	88.82	78.91	21.09	15.76	48.382	41.618	-0.06216	0.111723	0.099258
2	90.14	78.29	20.76	16.98	49.026	40.974	-0.07009	0.113384	0.098478
2.1	92.03	79.82	19.13	15.35	49.062	40.938	-0.02315	0.115761	0.100403
2.2	90.07	78.92	20.22	15.43	48.776	41.224	-0.00723	0.113296	0.09927
2.3	92.32	78.24	19.5	15.35	49.717	40.283	-0.04961	0.116126	0.098415
2.4	89.4	79.88	19.9	14.84	48.221	41.779	0.00363	0.112453	0.100478
2.5	92.21	78.02	18.77	16.14	49.765	40.235	0.04035	0.115987	0.098138
2.6	88.54	78.28	19.89	17.45	48.519	41.481	0.03259	0.111371	0.098465
2.7	90.48	78.39	20.57	16.02	49.095	40.905	-0.0854	0.113811	0.098604
2.8	88.92	77.56	19.55	16.51	48.904	41.096	-0.10802	0.111849	0.09756
2.9	89.3	77.59	19.74	17.03	49.016	40.984	-0.02715	0.112327	0.097597
3	88.85	78.22	18.18	16.48	48.638	41.362	-0.05779	0.111761	0.09839
3.1	89.24	78.87	19.28	14.91	48.53	41.47	-0.11724	0.112252	0.099208
3.2	89.42	78.37	20.08	16.19	48.77	41.23	-0.05207	0.112478	0.098579
3.3	89.96	79.86	19.9	15.4	48.402	41.598	-0.08307	0.113157	0.100453
3.4	89.04	79.48	22.08	14.98	48.247	41.753	0.04178	0.112	0.099975
3.5	91.23	78.76	19.78	15.86	49.195	40.805	-0.03629	0.114755	0.099069
3.6	88.47	79.74	19.27	15.53	47.971	42.029	-0.04206	0.111283	0.100302
3.7	89.22	77.5	19.38	17.77	49.023	40.977	-0.06531	0.112226	0.097484
3.8	88.71	78.72	18.8	14.22	48.416	41.584	0.06754	0.111585	0.099019
3.9	89.68	78.19	19.44	15.54	48.918	41.082	-0.06983	0.112805	0.098352
4	89.49	78.39	18.8	16.49	48.782	41.218	-0.03561	0.112566	0.098604
4.1	90.4	79.86	18.8	14.57	48.543	41.457	-0.01968	0.113711	0.100453
4.2	89.35	77.86	19.53	16.7	48.93	41.07	0.03532	0.11239	0.097937
4.3	87.96	78.72	19.76	15.28	48.176	41.824	0.08366	0.110642	0.099019
4.4	88.14	79	19.66	14.24	48.13	41.87	0.02298	0.110868	0.099371
4.5	89.91	78.83	19.15	15.79	48.759	41.241	0.01347	0.113094	0.099157
4.6	88.91	78.51	20.15	15.99	48.555	41.445	0.02876	0.111836	0.098755
4.7	88.29	78.99	19.07	15.54	48.183	41.817	-0.07067	0.111057	0.099358
4.8	88.88	78.66	19.28	15.22	48.491	41.509	0.00313	0.111799	0.098943
4.9	88.99	79.54	18.58	14.6	48.212	41.788	-0.07305	0.111937	0.10005
5	89.47	79.38	18.28	14.96	48.419	41.581	-0.09998	0.112541	0.099849
5.1	90.3	81.31	18.28	15	47.998	42.002	0.02852	0.113585	0.102277
5.2	89.05	79.6	19.31	15.78	48.207	41.793	-0.03785	0.112013	0.100126
5.3	91.43	79.72	18.08	14.67	48.912	41.088	-0.05671	0.115006	0.100277
5.4	90.73	80.2	19.67	14.29	48.525	41.475	-0.00563	0.114126	0.100881
5.5	89.05	79.82	19.34	15.77	48.13	41.87	0.0507	0.112013	0.100403
5.6	89.39	79.34	18.38	15.35	48.409	41.591	-0.00938	0.11244	0.099799
5.7	91.43	78.81	18.41	15.88	49.238	40.762	0.07067	0.115006	0.099132
5.8	90.77	78.99	18.43	16.84	48.97	41.03	0.08948	0.114176	0.099358
5.9	93	80.67	18.3	14.08	49.06	40.94	0.09171	0.116981	0.101472
6	90.43	79.07	18.32	15.78	48.836	41.164	-0.05897	0.113748	0.099459
6.1	91.18	80.13	19.38	15.45	48.692	41.308	-0.00212	0.114692	0.100792
6.2	91.73	79.75	18.5	15.74	48.996	41.004	-0.02191	0.115384	0.100314
6.3	88.16	80.04	19.59	15.43	47.762	42.238	-0.11807	0.110893	0.100679
6.4	91.02	80.1	17.63	15.12	48.651	41.349	-0.03912	0.114491	0.100755
6.5	90.65	80.02	20.39	15.3	48.566	41.434	-0.03516	0.114025	0.100654
6.6	91.13	79.75	17.53	14.94	48.809	41.191	-0.00543	0.114629	0.100314
6.7	90.16	79.37	19.25	15.76	48.642	41.358	0.05646	0.113409	0.099836

Table G.3. LDV Data: Forward Position, Outer Depth (10 Mar 98)

First-Stage Rotor LDV Data				Window Ave: on					
Date: 04/06/98				Axial Pos: -0.16ct					
N_Ref: 4822				Span Pos: 88%					
Vt= 792				t: .020					
Filter Settings: 5-30MHz				freq shifting: -10, 0					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
0	130.69	70.95	7.7	17.81	61.502	28.498	-0.63181	0.165013	0.089583
0.1	136.98	78.4	8.63	14.51	60.215	29.785	-0.00573	0.172955	0.09899
0.2	137.2	78.81	9.05	14.47	60.128	29.872	0.01199	0.173232	0.099508
0.3	136.3	78.68	8.49	14.43	60.003	29.997	0.05094	0.172096	0.099343
0.4	137.52	78.93	8.15	15.13	60.145	29.855	0.11372	0.173636	0.099659
0.5	135.67	79.24	8.64	14.42	59.711	30.289	0.003	0.171301	0.100051
0.6	136.43	78.83	8.68	14.97	59.98	30.02	0.00768	0.17226	0.099533
0.7	137.54	79.15	7.79	14.5	60.083	29.917	0.07967	0.173662	0.099937
0.8	136.42	79.24	7.64	15.37	59.85	30.15	0.00913	0.172247	0.100051
0.9	136.08	78.63	8.64	14.8	59.979	30.021	-0.04812	0.171818	0.09928
1	136.17	79.05	8.72	14.59	59.865	30.135	-0.07044	0.171932	0.099811
1.1	136.81	79.09	8.23	14.91	59.968	30.032	0.04358	0.17274	0.099861
1.2	138.11	79.79	8.04	13.96	59.983	30.017	0.02092	0.174381	0.100745
1.3	137.78	79.23	7.18	15.58	60.098	29.902	0.01362	0.173965	0.100038
1.4	137.46	79.89	7.11	14.21	59.836	30.164	-0.0204	0.173561	0.100871
1.5	137.49	80.57	7.43	14.55	59.63	30.37	-0.03442	0.173598	0.10173
1.6	137.01	80.06	7.81	12.97	59.7	30.3	0.02017	0.172992	0.101086
1.7	138.48	80.72	7.32	14.02	59.761	30.239	0.08416	0.174848	0.101919
1.8	138.61	82.02	7.58	13.03	59.385	30.615	-0.00511	0.175013	0.103561
1.9	139.65	80.61	7.17	14.45	60.007	29.993	0.06819	0.176326	0.10178
2	138.55	80.29	8.05	14.44	59.909	30.091	0.00002	0.174937	0.101376
2.1	139.68	79.66	6.96	14.45	60.305	29.695	0.05583	0.176364	0.100581
2.2	138.26	80.9	7.81	14.24	59.666	30.334	-0.02002	0.174571	0.102146
2.3	138.88	81.44	7.66	13.3	59.611	30.389	0.11235	0.175354	0.102828
2.4	139.59	81.25	6.43	12.92	59.799	30.201	0.00764	0.17625	0.102588
2.5	139.1	81.52	7.2	14.49	59.628	30.372	0.01986	0.175631	0.102929
2.6	140.03	80.18	6.89	14.55	60.204	29.796	-0.04733	0.176806	0.101237
2.7	140.13	81.44	7.44	14.67	59.836	30.164	-0.05601	0.176932	0.102828
2.8	139.49	80.63	8.14	15.07	59.97	30.03	0.02349	0.176124	0.101806
2.9	142.18	79.82	7.56	16.46	60.689	29.311	0.04166	0.17952	0.100783
3	141.78	80.39	6.6	15.13	60.448	29.552	-0.07635	0.179015	0.101503
3.1	141.43	80.48	8.2	14.46	60.358	29.642	0.03788	0.178573	0.101616
3.2	141.27	82.5	8.15	13.45	59.716	30.284	0.11021	0.178371	0.104167
3.3	142.53	80.25	7.92	15.25	60.62	29.38	-0.01026	0.179962	0.101326
3.4	141.08	81.13	8.21	14.1	60.098	29.902	0.0381	0.178131	0.102437
3.5	142.62	80.61	8.32	14.2	60.523	29.477	-0.03709	0.180076	0.10178
3.6	141.95	81.23	7.91	13.13	60.218	29.782	-0.04397	0.17923	0.102563
3.7	141.25	81.56	8.54	13.94	59.997	30.003	-0.03074	0.178346	0.10298
3.8	140.15	81.81	8.24	12.67	59.727	30.273	0.116	0.176957	0.103295
3.9	142.74	81.89	7.97	13.77	60.158	29.842	-0.06155	0.180227	0.103396
4	142.71	81.04	8.32	13.35	60.411	29.589	-0.00355	0.180189	0.102323
4.1	140.53	80.37	8.57	13.02	60.233	29.767	-0.05248	0.177437	0.101477
4.2	139.91	80.28	8.26	13.85	60.154	29.846	0.03311	0.176654	0.101364
4.3	141.71	81.22	7.62	13.97	60.181	29.819	0.10969	0.178927	0.102551
4.4	142.03	80.28	7.72	14.02	60.524	29.476	0.03276	0.179331	0.101364
4.5	139.59	80.86	8.41	14.33	59.917	30.083	-0.00348	0.17625	0.102096
4.6	140.89	81.43	7.8	13.29	59.974	30.026	0.0012	0.177891	0.102816
4.7	140.54	80.88	7.64	14.05	60.079	29.921	0.10951	0.177449	0.102121
4.8	140.69	81.6	8.15	13.91	59.888	30.112	-0.08739	0.177639	0.10303
4.9	140.33	79.78	8.65	14.23	60.381	29.619	0.04739	0.177184	0.100732
5	140.08	80.57	8.42	14.14	60.093	29.907	-0.00016	0.176869	0.10173
5.1	140.4	80.4	8.1	13.02	60.202	29.798	0.04035	0.177273	0.101515
5.2	140.23	81.22	8.34	14.05	59.92	30.08	0.09528	0.177058	0.102551
5.3	140.55	80.74	8.07	14.22	60.124	29.876	-0.00585	0.177462	0.101944
5.4	139.95	80.87	7.9	14.29	59.98	30.02	0.11067	0.176705	0.102109
5.5	141.17	80.14	8.39	14.1	60.415	29.585	-0.01518	0.178245	0.101187
5.6	140.35	81.63	7.48	14.47	59.817	30.183	0.07413	0.17721	0.103068
5.7	140.45	81.66	8.04	14.49	59.825	30.175	0.08438	0.177336	0.103106
5.8	140.04	79.91	8.64	14.42	60.29	29.71	0.00766	0.176818	0.100896
5.9	139.6	79.99	7.74	13.94	60.186	29.814	0.03894	0.176263	0.100997
6	139.9	80.66	8.55	14.21	60.036	29.964	0.0712	0.176641	0.101843
6.1	138.86	79.96	8.44	15.85	60.064	29.936	0.05263	0.175328	0.10096
6.2	139.54	80.41	8.95	14.46	60.048	29.952	0.04821	0.176187	0.101528
6.3	139.01	79.71	8.03	14.35	60.171	29.829	0.08445	0.175518	0.100644
6.4	140.06	81.18	7.9	13.97	59.903	30.097	0.07027	0.176843	0.1025
6.5	138.78	79.89	8.39	14.2	60.073	29.927	-0.07516	0.175227	0.100871
6.6	139.13	79.7	8.8	14.72	60.194	29.806	0.07884	0.175669	0.100631
6.7	139.03	80.77	8.38	13.41	59.844	30.156	0.01271	0.175543	0.101982

Table G.4. LDV Data: Forward Position, Inner Depth (06 Apr 98)

First-Stage Rotor LDV Data				Windows Ave: on					
Date: 04/06/98				Axial Pos: -0.16ct					
N_Ref: 4822				Span Pos: 93					
Vt= 792				t: .020					
Filter Settings: 5-30MHz				freq shifting: -10, 0					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
0	139.22	84.85	4.81	16.17	58.638	31.362	0.18534	0.175783	0.107134
0.1	140.24	78.68	8.83	16.13	60.706	29.294	0.05794	0.177071	0.099343
0.2	139.64	80.83	8.21	14.19	59.936	30.064	-0.01966	0.176313	0.102058
0.3	139.22	79.56	8.71	13.52	60.255	29.745	0.07432	0.175783	0.100455
0.4	138.75	79.78	8.4	14.41	60.102	29.898	-0.00915	0.175189	0.100732
0.5	138.58	79.61	8.71	13.83	60.122	29.878	0.01654	0.174975	0.100518
0.6	137.43	79.36	9.35	16.17	59.995	30.005	0.08993	0.173523	0.100202
0.7	138.58	78.75	9.12	14.96	60.393	29.607	0.01783	0.174975	0.099432
0.8	138.7	78.91	8.32	15.02	60.361	29.639	0.05902	0.175126	0.099634
0.9	138.75	79.43	8.54	13.59	60.211	29.789	0.07652	0.175189	0.10029
1	138.92	77.32	8.2	14.84	60.9	29.1	-0.01084	0.175404	0.097626
1.1	137.02	78.88	9.18	14.92	60.072	29.928	0.02723	0.173005	0.099596
1.2	138.31	78.11	8.17	14.87	60.543	29.457	0.00248	0.174634	0.098624
1.3	138.37	79.65	8.14	15.02	60.073	29.927	-0.0377	0.17471	0.100568
1.4	137.31	79.21	7.79	14.77	60.021	29.979	-0.03918	0.173371	0.100013
1.5	138.03	77.28	8.5	15.19	60.756	29.244	0.01731	0.17428	0.097576
1.6	137.15	79.7	8.32	14.25	59.84	30.16	0.01898	0.173169	0.100631
1.7	138.06	80.23	7.93	14.17	59.838	30.162	-0.06291	0.174318	0.101301
1.8	136.92	79.91	7.52	14.27	59.73	30.27	0.05045	0.172879	0.100896
1.9	137.68	80.46	8.11	13.7	59.696	30.304	-0.03038	0.173838	0.101591
2	136.39	78.85	8.53	14.27	59.966	30.034	0.02865	0.17221	0.099558
2.1	137.1	79.19	8.61	14.26	59.99	30.01	0.05251	0.173106	0.099987
2.2	136.46	80.35	8.79	13.77	59.508	30.492	-0.01192	0.172298	0.101452
2.3	136.74	79.06	7.58	14.24	59.964	30.036	-0.0967	0.172652	0.099823
2.4	137.73	80.23	8.05	14.39	59.778	30.222	0.02855	0.173902	0.101301
2.5	137.63	80.32	8.65	15.08	59.733	30.267	0.09274	0.173775	0.101414
2.6	138.62	80.13	8.35	14.98	59.97	30.03	0.01506	0.175025	0.101174
2.7	137.96	80.71	8.37	14.32	59.671	30.329	0.02836	0.174192	0.101907
2.8	137.55	80.18	8.34	14.3	59.76	30.24	-0.01867	0.173674	0.101237
2.9	138.67	80.52	7.34	13.88	59.858	30.142	0.02003	0.175088	0.101667
3	139.66	81.09	8.21	13.12	59.861	30.139	0.04417	0.176338	0.102386
3.1	138.09	80.65	8.49	13.98	59.715	30.285	-0.00659	0.174356	0.101831
3.2	139.3	81.41	7.99	13	59.696	30.304	-0.13965	0.175884	0.10279
3.3	139.62	79.15	8.01	14.97	60.451	29.549	0.03771	0.176288	0.099937
3.4	139.36	81.19	7.87	13.51	59.775	30.225	0.08127	0.17596	0.102513
3.5	139.73	81.4	8.27	13.73	59.778	30.222	-0.08664	0.176427	0.102778
3.6	139.35	81.42	8.14	13.06	59.703	30.297	-0.08137	0.175947	0.102803
3.7	140.07	80.71	7.63	13.89	60.048	29.952	-0.15607	0.176856	0.101907
3.8	139.95	80.78	8.5	13.58	60.006	29.994	-0.0726	0.176705	0.101995
3.9	139.66	81.67	7.4	13.85	59.681	30.319	-0.05851	0.176338	0.103119
4	141.18	80.53	7.59	14.43	60.301	29.699	-0.13149	0.178258	0.101679
4.1	140.51	80.78	8.3	14.14	60.105	29.895	-0.08418	0.177412	0.101995
4.2	141.73	80.75	7.51	14.24	60.328	29.672	0.05525	0.178952	0.101957
4.3	141.73	80.99	7.89	13.13	60.255	29.745	-0.04387	0.178952	0.10226
4.4	142.31	80.25	8.11	13.73	60.58	29.42	-0.01068	0.179684	0.101326
4.5	141.85	79.97	8.44	15.05	60.589	29.411	0.00897	0.179104	0.100972
4.6	142.06	80.39	8.43	14.37	60.495	29.505	-0.03294	0.179369	0.101503
4.7	141.75	80.45	8.57	14.41	60.423	29.577	-0.02628	0.178977	0.101578
4.8	141.28	80.98	8.21	15.45	60.181	29.819	0.02661	0.178384	0.102247
4.9	141.65	80.65	7.78	13.89	60.342	29.658	-0.114	0.178851	0.101831
5	142.03	80.2	7.64	14.44	60.547	29.453	-0.02925	0.179331	0.101263
5.1	141.43	79.85	8.43	14.98	60.552	29.448	0.0296	0.178573	0.100821
5.2	141.38	82.36	8.34	13.73	59.776	30.224	0.0096	0.17851	0.10399
5.3	141.75	80.69	8.52	15.38	60.351	29.649	-0.0211	0.178977	0.101881
5.4	141.56	80.98	8.19	14.84	60.228	29.772	0.02651	0.178737	0.102247
5.5	141.48	79.96	7.92	14.51	60.528	29.472	-0.03833	0.178636	0.10096
5.6	141.11	80.04	8.69	15.18	60.438	29.562	0.10243	0.178169	0.101061
5.7	141.58	80.22	8.22	14.72	60.465	29.535	-0.01878	0.178763	0.101288
5.8	141.86	80.32	8.42	14.63	60.483	29.517	0.04322	0.179116	0.101414
5.9	141.38	80.76	8.17	13.16	60.262	29.738	-0.02621	0.17851	0.10197
6	140.99	80.44	7.98	14.21	60.294	29.706	-0.02892	0.178018	0.101566
6.1	140.84	81.36	8.36	15.04	59.988	30.012	0.13426	0.177828	0.102727
6.2	139.93	80.87	8.17	14.5	59.974	30.026	0.00745	0.176679	0.102109
6.3	139.81	80.44	7.89	15.01	60.085	29.915	-0.02368	0.176528	0.101566
6.4	140.66	81.04	8.7	15.03	60.052	29.948	-0.04405	0.177601	0.102323
6.5	141.45	80.81	7.95	14.73	60.261	29.739	0.06218	0.178598	0.102033
6.6	140.49	80.24	8.72	14.57	60.268	29.732	0.1777	0.177386	0.101313
6.7	139.38	80.29	7.94	15.54	60.057	29.943	-0.07836	0.175985	0.101376

Table G.5. LDV Data: Forward Position, Middle Depth (06 Apr 98)

First-Stage Rotor LDV Data				Windows Ave: on					
Date: 040/06/98				Axial Pos: -0.16ct					
N_Rel: 4829				Span Pos: 98%					
Vt= 792				t: .020					
Filter Settings: 5-30MHz				freq shifting: -10, 0					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
0	140.87	74.8	8.38	15.47	62.032	27.968	-0.18935	0.177866	0.094444
0.1	140.37	78.64	8.18	16.73	60.739	29.261	-0.04676	0.177235	0.099293
0.2	140.6	79.13	8.82	16.16	60.63	29.37	0.09043	0.177525	0.099912
0.3	140.26	79.69	8.41	15.37	60.396	29.604	0.08226	0.177096	0.100619
0.4	139.14	78.37	9.76	16.28	60.61	29.39	0.07604	0.175682	0.098952
0.5	139.22	78.19	9.58	16.68	60.68	29.32	0.08233	0.175783	0.098725
0.6	139.92	77.33	8.81	17.48	61.07	28.93	0.07055	0.176667	0.097639
0.7	139.37	78.64	9.14	15.17	60.567	29.433	0.12795	0.175972	0.099293
0.8	139.34	77.3	9.84	17.17	60.98	29.02	0.08859	0.175934	0.097601
0.9	138.83	77.52	8.78	16.13	60.822	29.178	0.07075	0.17529	0.097879
1	138.6	78.23	9.14	17.07	60.56	29.44	0.0717	0.175	0.098775
1.1	139.67	76.12	10.32	19.26	61.41	28.59	0.02348	0.176351	0.096111
1.2	139.31	77.67	9.23	15.56	60.858	29.142	0.15637	0.175896	0.098068
1.3	139.26	79.25	9.63	15.05	60.358	29.642	0.07656	0.175833	0.100063
1.4	138.88	78.39	8.96	16	60.559	29.441	0.12128	0.175354	0.098977
1.5	138.35	77.75	9.98	16.68	60.664	29.336	0.07392	0.174684	0.098169
1.6	139.51	78.47	9.64	16.1	60.642	29.358	-0.00649	0.176149	0.099078
1.7	138.38	77.86	9.72	16.65	60.636	29.364	0.15516	0.174722	0.098308
1.8	137.46	77.89	9.72	15.4	60.462	29.538	0.10319	0.173561	0.098346
1.9	139.05	77.14	9.28	16.53	60.981	29.019	0.18437	0.175568	0.097399
2	137.8	78.28	10.12	17.12	60.4	29.6	0.04235	0.17399	0.098838
2.1	138.48	78.82	9.96	15.18	60.352	29.648	-0.04325	0.174848	0.09952
2.2	139.62	78.42	9.55	16.18	60.679	29.321	-0.00976	0.176288	0.099015
2.3	138.5	78.52	9.94	17	60.449	29.551	0.05996	0.174874	0.099141
2.4	138.97	78.2	9.41	15.41	60.632	29.368	0.11908	0.175467	0.098737
2.5	139.1	78.34	9.76	15.54	60.612	29.388	-0.03041	0.175631	0.098914
2.6	136.8	77.89	10.77	16.69	60.345	29.655	0.0718	0.172727	0.098346
2.7	138.16	77.28	10.93	16.03	60.78	29.22	0.0362	0.174444	0.097576
2.8	137.12	77.83	10.32	16.12	60.42	29.58	0.02592	0.173131	0.09827
2.9	138.98	77.2	10.04	16.63	60.949	29.051	0.05962	0.17548	0.097475
3	140.75	77.16	10.14	16.48	61.266	28.734	0.01633	0.177715	0.097424
3.1	138.58	77.74	11	16.72	60.709	29.291	0.04008	0.174975	0.098157
3.2	139.45	79.44	9.57	14.75	60.332	29.668	-0.04526	0.176073	0.100303
3.3	139.4	79.43	9.73	15.26	60.326	29.674	0.00412	0.17601	0.10029
3.4	139.27	79.87	9.68	15.03	60.166	29.834	0.01057	0.175846	0.100846
3.5	139.04	79.14	9.16	15.99	60.353	29.647	-0.07435	0.175556	0.099924
3.6	141.11	78.95	9.15	16.89	60.773	29.227	0.07228	0.178169	0.099684
3.7	139.35	79.01	9.23	14.63	60.448	29.552	0.09433	0.175947	0.09976
3.8	139.49	77.76	9.42	15.65	60.864	29.136	0.10141	0.176124	0.098182
3.9	140.99	78.04	9.04	17.13	61.035	28.965	0.02708	0.178018	0.098535
4	140.26	78	8.6	15.62	60.92	29.08	0.0391	0.177096	0.098485
4.1	140.48	78.42	9.19	15.61	60.827	29.173	0.02827	0.177374	0.099015
4.2	140.98	77.67	8.9	16.91	61.148	28.852	-0.14023	0.178005	0.098068
4.3	140.59	79.72	8.93	15.55	60.445	29.555	0.003	0.177513	0.100657
4.4	142.44	77.51	8.39	16.4	61.448	28.552	-0.00047	0.179848	0.097866
4.5	142.18	79.34	8.61	14.9	60.837	29.163	-0.05538	0.17952	0.100177
4.6	141.73	78.31	8.61	16.16	61.079	28.921	-0.07219	0.178952	0.098876
4.7	142.17	78.47	9.24	17	61.103	28.897	-0.11503	0.179508	0.099078
4.8	141.7	79.1	8.54	14.95	60.827	29.173	-0.08215	0.178914	0.099874
4.9	141.55	78.65	8.99	15.65	60.942	29.058	-0.0801	0.178725	0.099306
5	142.66	79.65	8.71	15.12	60.825	29.175	-0.03728	0.180126	0.100568
5.1	141.49	77.94	9.13	17.1	61.153	28.847	0.03847	0.178649	0.098409
5.2	139.91	78.83	8.4	16.09	60.601	29.399	-0.10625	0.176654	0.099533
5.3	141.99	79.54	8.04	14.9	60.744	29.256	0.01691	0.17928	0.100429
5.4	142.37	78.94	8.95	15.9	60.992	29.008	-0.01946	0.17976	0.099672
5.5	142.32	79.31	8.27	15.48	60.871	29.129	-0.05805	0.179697	0.100139
5.6	140.88	79.03	8.29	16.42	60.708	29.292	-0.04001	0.177879	0.099785
5.7	141.97	79.49	8.48	16.23	60.755	29.245	-0.03382	0.179255	0.100366
5.8	140.27	79.74	8.75	16.19	60.382	29.618	-0.03888	0.177109	0.100682
5.9	140.87	79.24	8.18	16.12	60.643	29.357	0.00642	0.177866	0.100051
6	140.67	79.87	8.02	16.23	60.411	29.589	-0.00842	0.177614	0.100846
6.1	141.1	78.54	7.48	17.1	60.897	29.103	-0.01699	0.178157	0.099167
6.2	140.28	81.04	8.89	15.25	59.983	30.017	0.02395	0.177121	0.102323
6.3	140.09	78.19	8.25	15.89	60.834	29.166	0.1008	0.176881	0.098725
6.4	139.59	81.24	8.33	14.67	59.801	30.199	-0.08841	0.17625	0.102576
6.5	140.6	80.78	7.91	15.42	60.122	29.878	-0.09192	0.177525	0.101995
6.6	139.4	79.66	8.58	15.17	60.254	29.746	0.04564	0.17601	0.100581
6.7	140.9	80.41	8.16	15.4	60.288	29.712	0.07052	0.177904	0.101528

Table G.6. LDV Data: Forward Position, Outer Depth (06 Apr 98)

First-Stage Rotor LDV Data				Window Ave: on					
Data: 04/06/98				Axial Pos: 0.35ct					
N_Ref: 4837				Span Pos: 93%					
Vt= 792				t: 020					
Filter Settings: 5-30 MHz				freq shifting: -10, 0					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
6.5	126.9	82.04	29.59	14.08	57.115	32.885	0.0163	0.160227	0.103586
6.6	118.26	81.58	33.51	14.6	55.402	34.598	0.05038	0.149318	0.103005
6.7	123.84	81.82	30.51	14.62	56.548	33.452	0.09091	0.156364	0.103308
6.8	124.22	82.2	30.27	14.64	56.506	33.494	0.05848	0.156843	0.103788
6.9	131.56	80.91	22.02	15.8	58.409	31.591	0.06249	0.166111	0.102159
7	131.39	81.36	19.49	14.44	58.232	31.768	-0.01061	0.165896	0.102727
7.1	130.5	81.36	20.18	14.3	58.057	31.943	-0.02838	0.164773	0.102727
7.2	129.86	80.61	20.79	15.15	58.17	31.83	-0.03414	0.163965	0.10178
7.3	132.43	81.82	17.63	14.26	58.291	31.709	-0.03484	0.16721	0.103308
7.4	133.06	81.89	17.33	14.2	58.391	31.609	-0.01856	0.168005	0.103396
7.5	135.6	80.47	13.34	15.01	59.313	30.687	-0.05765	0.171212	0.101604
7.6	137.61	81.41	10.91	15.04	59.391	30.609	0.00448	0.17375	0.10279
7.7	138.28	81.12	10.1	14.91	59.603	30.397	-0.00564	0.174596	0.102424
7.8	138.02	80.87	9.53	15.3	59.634	30.366	0.033	0.174268	0.102109
7.9	138.58	81.56	8.91	13.52	59.523	30.477	-0.00553	0.174975	0.10298
8	138.77	81.51	8.87	13.81	59.571	30.429	-0.06367	0.175215	0.102917
8.1	137.7	81.43	9.1	14.34	59.403	30.597	-0.02042	0.173864	0.102816
8.2	139.01	80.8	8.7	15.78	59.833	30.167	-0.04146	0.175518	0.10202
8.3	139.02	80.88	8.38	14.71	59.81	30.19	-0.01531	0.17553	0.102121
8.4	138.39	81.73	9.91	13.41	59.436	30.564	0.0809	0.174735	0.103194
8.5	138.85	80.48	8.74	16.27	59.903	30.097	0.04909	0.175316	0.101616
8.6	137.64	81.57	9.87	15.12	59.347	30.653	-0.03017	0.173788	0.102992
8.7	137.16	81.31	10.77	14.78	59.341	30.659	0.00274	0.173182	0.102664
8.8	137.67	81.61	10.65	14.07	59.341	30.659	-0.00272	0.173826	0.103043
8.9	137.91	81.86	11.07	15.25	59.307	30.693	-0.01965	0.174129	0.103359
9	138.45	82.32	10.54	13.37	59.264	30.736	-0.01531	0.174811	0.103939
9.1	139.05	81.41	10.97	14.78	59.652	30.348	-0.04167	0.175568	0.10279
9.2	138.01	83.43	11.93	14.69	58.845	31.155	0.07408	0.174255	0.105341
9.3	138.31	80.96	12.44	15.37	59.659	30.341	-0.0294	0.174634	0.102222
9.4	139.46	82.39	11.64	14.46	59.428	30.572	0.02161	0.176086	0.104028
9.5	139.84	81.21	10.97	14.41	59.856	30.144	0.06435	0.176566	0.102538
9.6	139.88	81.35	12.98	15.34	59.818	30.182	0.07745	0.176616	0.102715
9.7	142.56	81.97	10.92	13.82	60.103	29.897	0.1647	0.18	0.103497
9.8	141.82	81.71	14.49	15.54	60.053	29.947	0.0146	0.179066	0.103169
9.9	144.15	82.88	12.35	14.79	60.102	29.898	0.04292	0.182008	0.104646
10	142.54	82.04	14.26	14.69	60.077	29.923	0.02946	0.179975	0.103586
10.1	142.98	83.14	13.81	14.63	59.824	30.176	-0.08365	0.18053	0.104975
10.2	143	83.76	11.99	14.53	59.639	30.361	0.07716	0.180556	0.105758
10.3	144.01	82.91	14.24	14.24	60.071	29.929	-0.0517	0.181831	0.104684
10.4	145.68	82.64	13.97	15.26	60.434	29.566	0.03031	0.183939	0.104343

Table G.7. LDV Data: Center Position, Middle Depth (06 Apr 98)

First-Stage Rotor LDV Data				Windows Ave: on						
Date: 04/10/98				Axial Pos: -0.16ct						
N_Ref: 4830				Span Pos: 88%						
Vt: 798				t: .020						
Filter Settings: 5-30MHz				freq shifting: -10, 0						
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial	
0	123.75	86.9	12.04	10.91	54.924	35.076	0.12894	0.155075	0.108897	
0.1	136.46	78.87	15.29	15.42	59.974	30.026	-0.05406	0.171003	0.098835	
0.2	138.26	78.68	14.42	15.88	60.356	29.644	-0.03105	0.173258	0.098596	
0.3	138.48	79.58	14.5	16.32	60.114	29.886	-0.03517	0.173534	0.099724	
0.4	139.01	79.06	14.42	16.58	60.372	29.628	-0.03781	0.174198	0.099073	
0.5	139.78	78.11	14.88	15.88	60.802	29.198	0.02658	0.175163	0.097882	
0.6	140.66	78.55	15.86	15.89	60.818	29.182	-0.02612	0.176266	0.098434	
0.7	146.64	78.25	14.51	16.04	61.913	28.087	-0.11834	0.183759	0.098058	
0.8	145.63	78.25	15.44	15.89	61.751	28.249	-0.0735	0.182494	0.098058	
0.9	149.7	77.85	14.53	14.96	62.524	27.476	0.00934	0.187594	0.097556	
1	152.99	79.93	13.87	15.73	62.414	27.586	0.01906	0.191717	0.100163	
1.1	154.17	77.76	12.96	16.44	63.234	26.766	-0.07516	0.193195	0.097444	
1.2	159.82	77.3	9.96	15.36	64.189	25.811	-0.25141	0.200276	0.096867	
1.3	160.13	77.58	11.03	17.54	64.151	25.849	0.12723	0.200664	0.097218	
1.4	163.8	79.4	8.08	13.19	64.137	25.863	0.09617	0.205263	0.099499	
1.5	165.95	75.97	4.97	15.88	65.401	24.599	-0.01168	0.207957	0.095201	
1.6	166.1	75.95	4.7	15.8	65.429	24.571	-0.11656	0.208145	0.095175	
1.7	166.64	81.08	4.3	13.43	64.053	25.947	0.09759	0.208822	0.101604	
1.8	166.4	76.62	5.24	14.88	65.275	24.725	-0.04731	0.208521	0.096015	
1.9	167.2	82.24	2.68	14.13	63.809	26.191	-0.12805	0.209524	0.103058	
2	166.13	77.71	3.03	15.26	64.93	25.07	0.18082	0.208183	0.097381	
2.1	165.97	77.6	3.01	13.51	64.94	25.06	-0.17554	0.207982	0.097243	
2.2	166.36	80.03	5.03	13.14	64.311	25.689	0.06578	0.208471	0.100288	
2.3	165.72	75.39	4.33	15.41	65.536	24.464	0.17878	0.207669	0.094474	
2.4	166.15	78.6	1.82	16.37	64.683	25.317	0.23777	0.208208	0.098496	
2.5	167.15	78.34	2.01	14.93	64.888	25.112	-0.03386	0.209461	0.09817	
2.6	164.12	80.71	8.15	11.52	63.811	26.189	0.12226	0.205664	0.10114	
2.7	161.13	76.48	7.31	16.08	64.61	25.39	-0.01351	0.201917	0.09584	
2.8	156.8	82.6	15.79	11.22	62.22	27.78	-0.06723	0.196491	0.103509	
2.9	163.16	78.84	8.2	11.59	64.21	25.79	-0.10343	0.204461	0.098797	
3	148.89	75.8	16.96	12.89	63.019	26.981	-0.15975	0.186579	0.094987	
3.1	156.96	78.49	10.68	13.72	63.432	26.568	0.32277	0.196692	0.098358	
3.2	157.83	81.13	12.01	10.66	62.794	27.206	0.37052	0.197782	0.101667	
3.3	148.98	81.19	15.69	15.54	61.409	28.591	-0.30873	0.186692	0.101742	
3.4	144.3	80.2	15.73	12.08	60.937	29.063	-0.31709	0.180827	0.100501	
3.5	136.77	75.12	17.61	21.18	61.222	28.778	-0.10046	0.171391	0.094135	
3.6	133.48	79.31	16.25	10.85	59.282	30.718	-0.29507	0.167268	0.099386	
3.7	134.77	81.61	12.64	14.27	58.803	31.197	0.0425	0.168885	0.102268	
3.8	138.8	75.57	11.52	15.18	61.433	28.567	0.3418	0.173935	0.094699	
3.9	135.03	78.25	14.06	14.48	59.908	30.092	-0.30169	0.169211	0.098058	
4	133.09	79.81	13.87	14.06	59.051	30.949	0.0667	0.166779	0.100013	
4.1	130.83	79.78	14.31	13.93	58.626	31.374	-0.02148	0.163947	0.099975	
4.2	134.98	78.96	14.78	14.73	59.672	30.328	-0.11159	0.169148	0.098947	
4.3	134.07	79.29	13.42	14.84	59.4	30.6	-0.11198	0.168008	0.099361	
4.4	134.84	79.59	12.64	16.3	59.448	30.552	-0.10002	0.168972	0.099737	
4.5	134.5	78.77	14.11	14.81	59.644	30.356	0.01376	0.168546	0.098709	
4.6	135.17	79.17	13.54	14.94	59.644	30.356	0.00716	0.169386	0.099211	
4.7	133.82	79.26	13.21	15.87	59.362	30.638	-0.06831	0.167694	0.099323	
4.8	134.63	79.36	14.43	16.16	59.482	30.518	0.06261	0.168709	0.099449	
4.9	134.17	78.55	14.25	16.66	59.653	30.347	-0.0734	0.168133	0.098434	
5	134.55	79.34	13.27	15.32	59.475	30.525	0.12412	0.168609	0.099424	
5.1	133.2	78.83	13.5	15.08	59.381	30.619	0.06271	0.166917	0.098784	
5.2	134.44	79.83	12.75	14.32	59.3	30.7	-0.09282	0.168471	0.100038	
5.3	132.01	78.29	13.76	16.32	59.33	30.67	-0.0215	0.165426	0.098108	
5.4	134.67	78.97	13.22	15.7	59.613	30.387	-0.02353	0.168759	0.09896	
5.5	134.09	78.24	12.89	16.51	59.736	30.264	0.03888	0.168033	0.098045	
5.6	133.69	79.63	14.01	15.72	59.221	30.779	-0.00205	0.167531	0.099787	
5.7	133.95	79.78	13.16	15.49	59.222	30.778	0.05711	0.167857	0.099975	
5.8	133.9	78.96	13.33	15.83	59.472	30.528	-0.00675	0.167794	0.098947	
5.9	133.88	79.28	13.79	15.45	59.367	30.633	0.059	0.167769	0.099348	
6	135.34	79.13	13.45	15.84	59.688	30.312	0.02855	0.169599	0.09916	
6.1	133.09	79.58	13.74	15.52	59.121	30.879	-0.01195	0.166779	0.099724	
6.2	134.35	80.33	13.02	14.48	59.125	30.875	-0.01238	0.168358	0.100664	
6.3	133.93	79.49	13.66	15.41	59.313	30.687	-0.05362	0.167832	0.099612	
6.4	134.74	79.25	13.83	15.29	59.538	30.462	-0.00123	0.168847	0.099311	
6.5	133.71	79.19	13.75	15.61	59.363	30.637	0.01419	0.167556	0.099236	
6.6	135.57	80.08	13.75	14.69	59.432	30.568	-0.04507	0.169887	0.100351	
6.7	134.26	79.23	14.12	15.07	59.454	30.546	-0.03115	0.168246	0.099286	

Table G.8. LDV Data: Forward Position, Inner Depth (10 Apr 98)

First-Stage Rotor LDV Data				Window Ave: on					
Date: 04/10/98				Axial Pos: -.16ct					
N_Ret: 4818				Span Pos: 93%					
Vt= 799				t: .020					
Filter Settings: 5-30MHz				freq shifting: -10, 0					

Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
0	141.43	73.54	14.61	14.05	62.528	27.472	-0.25056	0.177009	0.09204
0.1	137.23	78.54	14.45	15.08	60.218	29.782	-0.06412	0.171752	0.098298
0.2	137.05	79.71	14.12	14.75	59.816	30.184	0.04053	0.171527	0.099762
0.3	137.84	77.82	14.37	15.15	60.55	29.45	-0.12855	0.172516	0.097397
0.4	140.16	78.76	14.54	14.5	60.666	29.334	-0.12014	0.175419	0.098573
0.5	141.27	77.96	15.18	15.4	61.109	28.891	-0.03378	0.176809	0.097572
0.6	142.31	78.89	15.26	15.7	60.998	29.002	-0.04078	0.17811	0.098736
0.7	147.19	78.33	15.21	15.56	61.979	28.021	-0.10103	0.184218	0.098035
0.8	148.97	77.31	14.22	15.47	62.571	27.429	0.01731	0.186446	0.096758
0.9	152.1	78.41	13.93	13.23	62.728	27.272	-0.18841	0.190363	0.098135
1	153.35	76.01	13.15	13.59	63.634	26.366	-0.02312	0.191927	0.095131
1.1	153.83	79.54	14.02	13.9	62.657	27.343	-0.20605	0.192528	0.099549
1.2	158.71	77.09	10.95	15.2	64.092	25.908	-0.02761	0.198636	0.096483
1.3	155.46	76.37	12.97	16.65	63.838	26.162	0.0184	0.194568	0.095582
1.4	161.32	75.77	10.03	14.66	64.84	25.16	-0.00893	0.201902	0.094831
1.5	162.75	77.01	7.12	14.42	64.676	25.324	0.04443	0.203692	0.096383
1.6	163.75	79.14	6.32	12.3	64.204	25.796	0.08021	0.204944	0.099049
1.7	163.86	76.92	6.73	13.98	64.854	25.146	0.16445	0.205081	0.09627
1.8	164.55	78.45	5.56	13.96	64.51	25.49	0.03298	0.205945	0.098185
1.9	163.53	77.25	5.16	14.98	64.714	25.286	0.03337	0.204668	0.096683
2	165.03	78.09	3.49	17.15	64.679	25.321	0.03253	0.206546	0.097735
2.1	162.13	78.23	8.56	14.32	64.242	25.758	-0.07229	0.202916	0.09791
2.2	163.17	76.61	5.75	15.98	64.848	25.152	0.04657	0.204218	0.095882
2.3	165.33	76.81	4.48	13.99	65.082	24.918	0.01563	0.206921	0.096133
2.4	165.21	78.85	4.37	14.39	64.486	25.514	-0.04312	0.206771	0.098686
2.5	165.85	77.03	3.33	15.01	65.087	24.913	-0.16473	0.207572	0.096408
2.6	165.1	78.63	4.98	14.7	64.535	25.465	0.01671	0.206633	0.098411
2.7	163.88	77.58	5.03	16.7	64.666	25.334	0.11432	0.205106	0.097096
2.8	162.34	76.11	6.57	15.6	64.881	25.119	-0.13607	0.203179	0.095257
2.9	160.31	76.76	9.54	15.71	64.414	25.586	-0.03273	0.200638	0.09607
3	158.07	79.21	10.31	12.35	63.384	26.616	0.03599	0.197835	0.099136
3.1	159.07	80.47	10.48	11.96	63.167	26.833	-0.14399	0.199086	0.100713
3.2	159.31	77.69	7.48	13.98	64.002	25.998	0.23919	0.199387	0.097234
3.3	156.69	76.39	11.68	15.77	64.011	25.989	-0.18699	0.196108	0.095607
3.4	157.18	77.82	11.69	14.81	63.658	26.342	-0.02203	0.196721	0.097397
3.5	150.92	78.75	12.35	15.19	62.443	27.557	0.03985	0.188886	0.098561
3.6	145.82	78.01	11.21	15.76	61.853	28.147	-0.18009	0.182503	0.097635
3.7	148.16	76.36	12.36	15.77	62.733	27.267	0.14063	0.185432	0.095569
3.8	144.51	75.67	12.65	15.96	62.362	27.638	-0.00922	0.180864	0.094706
3.9	138.18	78.02	15.22	16.41	60.55	29.45	0.10653	0.172941	0.097647
4	144.76	77.36	13.04	14.4	61.878	28.122	-0.06237	0.181176	0.096821
4.1	140.74	75.64	14.51	15.92	61.745	28.255	-0.00093	0.176145	0.094668
4.2	138.81	77.68	13.42	13.53	60.769	29.231	0.05416	0.17373	0.097222
4.3	136.07	78.78	14.24	15.25	59.93	30.07	0.05977	0.1703	0.098598
4.4	134.97	79.07	13.35	14.62	59.636	30.364	-0.04716	0.168924	0.098961
4.5	136.19	79.24	13.3	14.93	59.806	30.194	-0.02902	0.170451	0.099174
4.6	135.65	78.52	13.65	14.67	59.936	30.064	0.02662	0.169775	0.098273
4.7	135.39	79.04	13.64	14.37	59.722	30.278	0.00189	0.169449	0.098924
4.8	136.53	78.9	13.09	15.49	59.977	30.023	0.14838	0.170876	0.098748
4.9	135.4	80.42	13.27	13.82	59.291	30.709	0.08466	0.169462	0.100651
5	135.32	79.69	14	14.41	59.507	30.493	-0.07929	0.169362	0.099737
5.1	136.04	79.52	13.61	14.28	59.693	30.307	0.10312	0.170263	0.099524
5.2	134.3	79.57	13.27	14	59.354	30.646	-0.01006	0.168085	0.099587
5.3	134.46	79.22	13.13	15.26	59.494	30.506	0.0363	0.168285	0.099149
5.4	135.88	79.38	12.77	14.42	59.709	30.291	0.02817	0.170063	0.099349
5.5	135.27	78.36	13.97	15.76	59.916	30.084	0.11299	0.169299	0.098073
5.6	134.82	79.02	13.08	14.67	59.625	30.375	-0.00249	0.168736	0.098899
5.7	136.29	80.13	13.03	14.63	59.548	30.452	-0.03958	0.170576	0.100288
5.8	134.78	79.19	13.04	14.15	59.564	30.436	-0.00461	0.168686	0.099111
5.9	134.25	79.29	12.89	15.29	59.431	30.569	-0.06842	0.168023	0.099237
6	135.24	78.54	13.79	15.13	59.852	30.148	0.02517	0.169262	0.098298
6.1	136.15	79.38	13.15	15.3	59.756	30.244	-0.06362	0.170401	0.099349
6.2	135.87	78.82	12.87	15.43	59.882	30.118	-0.06495	0.17005	0.098648
6.3	135.19	79.04	12.47	14.88	59.687	30.313	-0.03359	0.169199	0.098924
6.4	136.41	79.25	12.94	15.17	59.845	30.155	-0.06006	0.170726	0.099186
6.5	136.28	80.05	12.88	13.81	59.569	30.431	0.04179	0.170563	0.100188
6.6	136.48	79.51	12.97	14.97	59.777	30.223	0.00444	0.170814	0.099512
6.7	136.36	79.68	13.88	14.13	59.699	30.301	-0.02604	0.170663	0.099725

Table G.9. LDV Data: Forward Position, Middle Depth (10 Apr 98)

First-Stage Rotor LDV Data				Windows Ave: on					
Date: 04/10/98				Axial Pos: -0.16ct					
N_Ref: 4781				Span Pos: 98%					
Vt= 795				t: .020					
Filter Settings: 5-30MHz				freq shifting: -10, 0					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
0	138.78	76.55	14.61	12.45	61.12	28.88	-0.25584	0.174566	0.096289
0.1	140.3	77.14	13.76	17	61.198	28.802	-0.10338	0.176478	0.097031
0.2	141.18	74.77	13.6	17.77	62.094	27.906	-0.09273	0.177585	0.09405
0.3	141.13	75.75	13.63	17.12	61.777	28.223	-0.06835	0.177522	0.095283
0.4	143.49	75.4	13.89	17.2	62.279	27.721	-0.22977	0.180491	0.094843
0.5	147.19	74.55	13.48	17.79	63.138	26.862	-0.08428	0.185145	0.093774
0.6	145.08	75.26	14.5	16.8	62.583	27.417	-0.03522	0.182491	0.094667
0.7	146.8	73.5	13.32	18.87	63.404	26.596	-0.13989	0.184654	0.092453
0.8	150.03	74.24	13.11	18.66	63.671	26.329	-0.12441	0.188717	0.093384
0.9	149.46	73.55	12.95	17.91	63.799	26.201	-0.06169	0.188	0.092516
1	151.18	72.19	11.96	18.63	64.474	25.526	-0.1774	0.190164	0.090805
1.1	154.76	71.08	10.8	19.88	65.332	24.668	0.02516	0.194667	0.089409
1.2	153.02	72.42	11.39	19.28	64.674	25.326	-0.08054	0.192478	0.091094
1.3	155.59	72.71	9.57	17.87	64.953	25.047	-0.03544	0.195711	0.091459
1.4	154.14	72.17	11.23	17.92	64.909	25.091	0.0645	0.193887	0.09078
1.5	153.11	70.92	11.01	19.58	65.147	24.853	0.00641	0.192591	0.089208
1.6	152.59	71.34	10.34	21.52	64.941	25.059	0.08069	0.191937	0.089736
1.7	151.05	71.19	11.57	19.69	64.767	25.233	0.09514	0.19	0.089547
1.8	151.16	71.31	12.04	20.52	64.743	25.257	-0.12533	0.190138	0.089698
1.9	152.25	72.54	11.44	18.37	64.525	25.475	-0.0665	0.191509	0.091245
2	150.66	73.16	12.45	19	64.1	25.9	-0.01796	0.189509	0.092025
2.1	149.5	72.3	11.69	18.28	64.189	25.811	0.07929	0.18805	0.090943
2.2	150.11	72.55	11.75	19.07	64.205	25.795	-0.11312	0.188818	0.091258
2.3	151.04	73.01	11.22	19.11	64.2	25.8	0.07579	0.189987	0.091836
2.4	149.9	72.9	11.47	18.93	64.067	25.933	0.04236	0.188553	0.091698
2.5	150.16	73.71	12.57	17.93	63.854	26.146	-0.07194	0.188881	0.092717
2.6	147.89	73.14	12.57	18.16	63.684	26.316	0.03384	0.186025	0.092
2.7	146.45	71.38	13.15	19.01	64.015	25.985	0.15164	0.184214	0.089786
2.8	148.25	73.51	11.14	19.25	63.626	26.374	-0.00436	0.186478	0.092465
2.9	147.16	74.63	12.7	18.4	63.11	26.89	0.0604	0.185107	0.093874
3	148.86	72.53	12.57	18.93	64.023	25.977	-0.04883	0.187245	0.091233
3.1	150.65	71.8	11.31	19.38	64.518	25.482	0.06187	0.189497	0.090314
3.2	150.25	71.52	11.45	18.6	64.545	25.455	0.14687	0.188994	0.089962
3.3	147.93	74.24	12.89	19.08	63.35	26.65	0.06335	0.186075	0.093384
3.4	147.82	73.29	13.19	17.56	63.629	26.371	0.0106	0.185937	0.092189
3.5	149.64	73.2	11.53	19.19	63.934	26.066	-0.09837	0.188226	0.092075
3.6	148.74	72.83	13.19	18.31	63.912	26.088	0.12926	0.187094	0.09161
3.7	150.39	73.41	10.94	17.46	63.98	26.02	-0.01168	0.18917	0.09234
3.8	149.38	73.67	11.79	16.88	63.748	26.252	-0.09724	0.187899	0.092667
3.9	148.34	73.93	12.32	18	63.509	26.491	0.0327	0.186591	0.092994
4	150.59	74.83	12.01	16.3	63.577	26.423	-0.14935	0.189421	0.094126
4.1	148.58	75.93	13.42	16.57	62.932	27.068	-0.14502	0.186893	0.095509
4.2	146.33	73.32	13.33	19.55	63.386	26.614	-0.12219	0.184063	0.092226
4.3	141.23	75.01	13.82	17.59	62.028	27.972	-0.02923	0.177648	0.094352
4.4	144.12	74	13.54	17.16	62.821	27.179	-0.0786	0.181283	0.093082
4.5	140.04	76.63	14.07	15.77	61.312	28.688	-0.06043	0.176151	0.09639
4.6	137.94	76.45	14.65	16.88	61.003	28.997	0.07189	0.173509	0.096164
4.7	134.7	75.56	14.69	17.19	60.708	29.292	0.03179	0.169434	0.095044
4.8	136.62	76.5	14.5	17.22	60.754	29.246	-0.11441	0.171849	0.096226
4.9	135.33	76.44	14.61	15.36	60.54	29.46	0.04086	0.170226	0.096151
5	137.07	77.8	13.53	16.76	60.422	29.578	-0.04316	0.172415	0.097862
5.1	137.03	75.55	14.09	18.52	61.129	28.871	0.07761	0.172365	0.095031
5.2	135.08	75.7	13.65	16.34	60.736	29.264	0.01279	0.169912	0.09522
5.3	135.35	75.9	13.65	17.22	60.717	29.283	0.07304	0.170252	0.095472
5.4	135.87	76.28	12.6	15.93	60.689	29.311	0.09693	0.170906	0.09595
5.5	134.32	76.43	13.12	16.38	60.36	29.64	-0.04068	0.168956	0.096138
5.6	133.58	76.01	13.12	16.67	60.359	29.641	-0.01596	0.168025	0.09561
5.7	135.36	76.21	13.65	15.79	60.62	29.38	0.06314	0.170264	0.095862
5.8	134.87	75.88	13.53	17.82	60.638	29.362	-0.07225	0.169648	0.095447
5.9	135.23	77.37	12.96	15.92	60.225	29.775	0.00744	0.170101	0.097321
6	135.28	77.65	13.55	15.86	60.145	29.855	-0.01193	0.170164	0.097673
6.1	134.3	76.1	13.36	16.45	60.461	29.539	0.0217	0.168931	0.095723
6.2	135.23	76.51	13.34	16.42	60.5	29.5	-0.0355	0.170101	0.096239
6.3	136.54	77.2	13.7	16.33	60.516	29.484	0.11697	0.171748	0.097107
6.4	136.04	76.25	13.29	16.65	60.728	29.272	-0.02126	0.171119	0.095912
6.5	136.49	75.78	13.78	17.52	60.96	29.04	-0.05393	0.171686	0.095321
6.6	137.83	77.17	13.07	16.05	60.756	29.244	-0.057	0.173371	0.097069
6.7	138.49	76.42	13.46	17.44	61.112	28.888	-0.10807	0.174201	0.096126

Table G.10. LDV Data: Forward Position, Outer Depth (10 Apr 98)

Date: 04/10/98				Axial Pos: 0.35ct					
N_Ref: 4840				Span Pos: 88%					
Vt= 794				t: .020					
Filter Settings: 5-30MHz				freq shifting: -10, 0					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
7.8	123.59	70.56	9.55	1.67	60.277	29.723	-0.07317	0.155655	0.088866
7.9	126.26	70.54	9.06	3.03	60.81	29.19	0.08784	0.159018	0.088841
8	125.16	70.46	9.41	1.79	60.622	29.378	0.01045	0.157632	0.088741
8.1	123.38	70.56	10.05	4.1	60.234	29.766	0.04685	0.15539	0.088866
8.2	120.46	70.26	10.32	1.93	59.744	30.256	0.09659	0.151713	0.088489
8.3	118.88	70.39	9.14	3.21	59.37	30.63	0.06307	0.149723	0.088652
8.4	119.27	70.24	9.88	2.13	59.506	30.494	0.15021	0.150214	0.088463
8.5	118.11	70.43	9.84	3.3	59.194	30.806	0.08778	0.148753	0.088703
8.6	114.67	70.3	8.08	2.62	58.487	31.513	0.17314	0.144421	0.088539
8.7	113.21	70.24	6.8	2.11	58.182	31.818	0.08129	0.142582	0.088463
8.8	112.71	70.21	6.12	2.22	58.08	31.92	0.12615	0.141952	0.088426
8.9	112.03	70.17	5.23	2.13	57.941	32.059	0.06769	0.141096	0.088375
9	112.05	70.25	4.99	2.28	57.914	32.086	0.05745	0.141121	0.088476
9.1	111.82	70.35	4.93	2.09	57.824	32.176	0.04402	0.140831	0.088602
9.2	111.74	70.45	4.76	1.95	57.771	32.229	0.04235	0.14073	0.088728

Table G.11. LDV Data: Center Position, Inner Depth (10 Apr 98)

First-Stage Rotor LDV Data				Window Ave: on					
Date: 04/10/98				Axial Pos: 0.35ct					
N_Ref: 4840				Span Pos: 93%					
Vt= 794				t: .020					
Filter Settings: 5-30MHz				freq shifting: -10,0					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
7.8	123.58	70.29	10.4	2.57	60.367	29.633	-0.03169	0.155642	0.088526
7.9	126.25	70.97	10.91	4.03	60.657	29.343	0.06304	0.159005	0.089383
8	123.69	70.55	9.3	1.9	60.299	29.701	0.06285	0.155781	0.088854
8.1	123.64	70.98	9.98	3.02	60.14	29.86	0.08219	0.155718	0.089395
8.2	119.75	70.56	8.66	1.91	59.494	30.506	-0.02498	0.150819	0.088866
8.3	119.44	70.84	8.93	2.86	59.329	30.671	0.08907	0.150428	0.089219
8.4	118.82	70.64	9.25	2.22	59.268	30.732	-0.11776	0.149647	0.088967
8.5	117.37	70.65	7.85	1.9	58.955	31.045	-0.0312	0.147821	0.08898
8.6	116.15	70.75	6.81	2.38	58.654	31.346	0.0465	0.146285	0.089106
8.7	115.26	70.62	5.37	2.21	58.504	31.496	0.0486	0.145164	0.088942
8.8	114.89	70.72	4.8	1.98	58.387	31.613	0.00995	0.144698	0.089068
8.9	114.44	70.75	4	1.88	58.275	31.725	0.00664	0.144131	0.089106
9	114.42	70.79	3.73	1.82	58.255	31.745	-0.01951	0.144106	0.089156
9.1	114.35	70.89	3.33	1.7	58.206	31.794	0.01004	0.144018	0.089282
9.2	114.22	70.94	2.99	1.65	58.154	31.846	0.00273	0.143854	0.089345

Table G.12. LDV Data: Center Position, Middle Depth (10 Apr 98)

First-Stage Rotor LDV Data				Windows Ave: on					
Date: 04/10/98				Axial Pos: 0.35ct					
N_Ref: 4834				Span Pos: 98%					
Vt= 794				t: .020					
Filter Settings: 5-30MHz				freq shifting: -10, 0					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
7.2	115.35	70.33	2.52	2.24	58.628	31.372	0.04593	0.145277	0.088577
7.3	117.62	70.49	6.26	2.41	59.067	30.933	0.01959	0.148136	0.088778
7.4	123.17	70.46	9.75	3.85	60.228	29.772	0.04412	0.155126	0.088741
7.5	121.4	70.63	6.75	2.27	59.81	30.19	0.1367	0.152897	0.088955
7.6	120.94	70.48	9.8	2.22	59.768	30.232	0.01417	0.152317	0.088766
7.7	116.68	70.46	5.16	2.52	58.871	31.129	0.06756	0.146952	0.088741
7.8	118.62	70.51	7.15	2.33	59.272	30.728	0.05235	0.149395	0.088804
7.9	119.2	70.55	7.56	2.4	59.379	30.621	0.11228	0.150126	0.088854
8	118.87	70.53	8.99	2.34	59.317	30.683	0.05955	0.14971	0.088829
8.1	116.93	70.72	5.48	2.19	58.833	31.167	0.0475	0.147267	0.089068
8.2	116.22	70.61	5.06	2.38	58.721	31.279	-0.01103	0.146373	0.088929
8.3	116.4	70.71	4.9	2.25	58.723	31.277	-0.02043	0.146599	0.089055
8.4	116.23	70.74	4.47	2.47	58.674	31.326	0.02216	0.146385	0.089093
8.5	115.4	70.81	3.76	2.25	58.466	31.534	-0.03044	0.14534	0.089181
8.6	115.5	70.69	2.79	2.26	58.533	31.467	-0.03482	0.145466	0.08903
8.7	115.39	70.8	2.24	2.35	58.469	31.531	0.05827	0.145327	0.089169
8.8	115.33	70.91	1.96	2.19	58.416	31.584	-0.01746	0.145252	0.089307
8.9	115.3	71.01	1.55	2.08	58.373	31.627	0.01469	0.145214	0.089433

Table G.13. LDV Data: Center Position, Outer Depth (10 Apr 98)

First Stage Rotor LDV Data				Window Ave: On					
Date: 05/01/98				Axial Pos: -.16ct					
N Ref: 4803				Span Pos: 88%					
Vt= 792				t: .020 in					
Filter Setting: 5-30MHz				freq shifting: -10, 0					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
0	131.89	77.58	16.13	19.38	59.534	30.466	0.42977	0.166528	0.097955
0.1	137.76	80.39	8.92	13.7	59.734	30.266	-0.03889	0.173939	0.101503
0.2	136.16	78.17	9.56	15.48	60.142	29.858	0.09032	0.171919	0.098699
0.3	136.39	77.99	9.02	15.31	60.238	29.762	0.14206	0.17221	0.098472
0.4	135.54	77.89	9.68	16.46	60.117	29.883	0.05349	0.171136	0.098346
0.5	132.46	77.28	9.53	15.15	59.738	30.262	0.15053	0.167247	0.097576
0.6	132.06	77.73	9.65	14.59	59.519	30.481	0.13236	0.166742	0.098144
0.7	131.91	79.34	9.05	14.77	58.976	31.024	-0.03016	0.166553	0.100177
0.8	129.17	79.52	7.99	15.22	58.382	31.618	0.13975	0.163093	0.100404
0.9	129.12	78.78	7.83	15.37	58.613	31.387	0.24665	0.16303	0.09947
1	128.39	78.97	7.78	15.46	58.405	31.595	0.07748	0.162109	0.09971
1.1	128.41	77.41	7.56	14.91	58.916	31.084	0.25487	0.162134	0.09774
1.2	127.01	77.52	7.34	14.39	58.602	31.398	0.1399	0.160366	0.097879
1.3	126.83	81.04	6.25	12.92	57.422	32.578	-0.036	0.160139	0.102323
1.4	127.18	78.34	7.74	14.29	58.367	31.633	0.18194	0.160581	0.098914
1.5	127.26	80.45	5.86	13.81	57.702	32.298	0.15034	0.160682	0.101578
1.6	128.7	79.51	7.04	13.99	58.292	31.708	0.1629	0.1625	0.100391
1.7	128.99	78.25	7.56	15	58.758	31.242	0.02238	0.162866	0.098801
1.8	129.69	82.43	7.26	11.33	57.561	32.439	0.03521	0.16375	0.104078
1.9	130.11	80.01	6.15	13.06	58.41	31.59	0.11192	0.16428	0.101023
2	130.2	78.08	7.14	16.51	59.049	30.951	0.12487	0.164394	0.098586
2.1	133.73	79.56	6.98	14.57	59.251	30.749	0.00533	0.168851	0.100455
2.2	130.97	79.15	7.61	14.86	58.856	31.144	0.03991	0.165366	0.099937
2.3	131.26	81.21	6.84	13.34	58.254	31.746	0.15777	0.165732	0.102538
2.4	131.95	80.47	7.71	12.75	58.623	31.377	0.09303	0.166604	0.101604
2.5	132.99	79.94	7.13	13.18	58.989	31.011	0.08551	0.167917	0.100934
2.6	134	81.22	6.67	13.38	58.78	31.22	0.01798	0.169192	0.102551
2.7	133.41	82.41	7.09	12.98	58.295	31.705	-0.08447	0.168447	0.104053
2.8	137.35	80.69	8.02	14.02	59.566	30.434	0.15167	0.173422	0.101881
2.9	137.67	78.17	7.49	16.35	60.411	29.589	0.13228	0.173826	0.098699
3	137.86	80.47	7.92	13.86	59.729	30.271	-0.01352	0.174066	0.101604
3.1	137.71	81.16	7.59	13.3	59.487	30.513	0.09982	0.173876	0.102475
3.2	138.84	80.51	7.16	15.01	59.891	30.109	0.04131	0.175303	0.101654
3.3	141.59	78.59	7.05	15.81	60.967	29.033	-0.05788	0.178775	0.09923
3.4	140.74	81.71	7.42	14.7	59.862	30.138	-0.03176	0.177702	0.103169
3.5	141	81.07	7.66	13.55	60.104	29.896	-0.07256	0.17803	0.102361
3.6	141.22	82.62	7.18	12.01	59.671	30.329	-0.01082	0.178308	0.104318
3.7	143.97	81.01	7.83	13.83	60.636	29.364	-0.09836	0.18178	0.102285
3.8	143.62	78.88	7.11	15.85	61.225	28.775	0.0805	0.181338	0.099596
3.9	143.42	78.7	7.46	15.19	61.245	28.755	0.06661	0.181086	0.099369
4	143.83	79.75	7.81	15.63	60.993	29.007	0.12572	0.181604	0.100694
4.1	145.09	81.71	7.4	13.96	60.612	29.388	0.00645	0.183194	0.103169
4.2	143.95	81.22	7.76	13.53	60.568	29.432	-0.01511	0.181755	0.102551
4.3	142.2	80.1	9.09	13.24	60.608	29.392	-0.02151	0.179545	0.101136
4.4	145.06	79.69	8.14	14.9	61.218	28.782	-0.02712	0.183157	0.100619
4.5	143.14	80.24	8.39	15.25	60.727	29.273	0.0011	0.180732	0.101313
4.6	142.34	79.82	9.35	15.32	60.718	29.282	0.035	0.179722	0.100783
4.7	141.65	79.05	9.81	15.06	60.837	29.163	0.03376	0.178851	0.099811
4.8	142.4	80.76	8.37	13.91	60.441	29.559	-0.0524	0.179798	0.10197
4.9	141.65	80.86	9.06	13.95	60.28	29.72	0.03939	0.178851	0.102096
5	141.93	79.39	8.33	14.82	60.78	29.22	-0.01866	0.179205	0.10024
5.1	142.15	80.12	8.91	14.53	60.595	29.405	0.10516	0.179482	0.101162
5.2	141.99	80.09	9.04	13.37	60.575	29.425	-0.04046	0.17928	0.101124
5.3	140.99	78.18	8.93	16.07	60.991	29.009	0.04449	0.178018	0.098712
5.4	141.11	79.22	8.53	14.62	60.69	29.31	-0.05368	0.178169	0.100025
5.5	140.6	79.15	8.11	15.43	60.622	29.378	0.02095	0.177525	0.099937
5.6	141.03	79.92	8.78	14.95	60.461	29.539	-0.06703	0.178068	0.100909
5.7	139.17	79.53	9.04	15.08	60.254	29.746	0.02913	0.17572	0.100417
5.8	139.7	79.7	8.88	15.46	60.295	29.705	0.01688	0.176389	0.100631
5.9	139.79	79.66	8.38	14.36	60.323	29.677	-0.04369	0.176503	0.100581
6	140.45	80.07	8.5	14.37	60.311	29.689	0.02597	0.177336	0.101098
6.1	139.97	79.35	8.84	14.88	60.453	29.547	0.04822	0.17673	0.100189
6.2	140.05	79.72	8.53	15.23	60.351	29.649	0.07042	0.176831	0.100657
6.3	140.11	79.44	8.52	14.96	60.446	29.554	0.04431	0.176907	0.100303
6.4	140.07	79.31	8.5	15.4	60.481	29.519	-0.03467	0.176856	0.100139
6.5	139.38	79.39	8.87	14.46	60.335	29.665	0.01859	0.175985	0.10024
6.6	139.39	79.81	8.97	14.87	60.204	29.796	0.04049	0.175997	0.10077
6.7	139.37	79.69	8.75	15.28	60.24	29.76	0.0625	0.175972	0.100619

Table G.14. LDV Data: Forward Position, Inner Depth (01 Apr 98)

First Stage Rotor LDV Data				Window Ave: On					
Date: 05/01/98				Axial Pos: -.16ct					
N_Ref: 4808				Span Pos: 93%					
Vt= 794				t: .020 in					
Filter Setting: 5-30MHz				freq shifting: -10, 0					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
0	139.94	92.02	0.02	0.02	56.671	33.329	-0.44882	0.176247	0.115894
0.1	135.25	77.47	8.76	14.23	60.195	29.805	0.13564	0.17034	0.097569
0.2	133.88	78.73	8.17	13.97	59.542	30.458	0.12798	0.168615	0.099156
0.3	132.8	75.68	8.08	15.8	60.323	29.677	0.11701	0.167254	0.095315
0.4	132.03	76.63	7.99	14.49	59.868	30.132	0.01025	0.166285	0.096511
0.5	129.31	76.75	6.59	13.66	59.31	30.69	0.123	0.162859	0.096662
0.6	129.86	76.91	7.61	14.66	59.364	30.636	0.10069	0.163552	0.096864
0.7	129.57	77.13	7.32	14.73	59.236	30.764	0.10346	0.163186	0.097141
0.8	128.99	76.75	7.38	14.76	59.248	30.752	0.20784	0.162456	0.096662
0.9	128.55	77.26	6	13.6	58.994	31.006	0.14189	0.161902	0.097305
1	129.3	77.95	6.45	13.66	58.915	31.085	0.07754	0.162846	0.098174
1.1	128.68	77.49	6.41	12.92	58.942	31.058	0.20261	0.162065	0.097594
1.2	129.6	77.3	5.85	15.57	59.187	30.813	0.19347	0.163224	0.097355
1.3	129.8	77.79	5.41	13.5	59.065	30.935	0.21946	0.163476	0.097972
1.4	130.01	79.03	5.67	13.67	58.703	31.297	0.18434	0.163741	0.099534
1.5	129.55	78.65	5.39	12.76	58.738	31.262	0.12325	0.163161	0.099055
1.6	130.47	79.35	5.8	13.65	58.695	31.305	0.17314	0.16432	0.099937
1.7	129.51	78.75	6.4	13.3	58.697	31.303	0.22159	0.163111	0.099181
1.8	131.54	79.21	6.32	14.51	58.946	31.054	0.08956	0.165668	0.099761
1.9	130.74	79.23	6.7	14.84	58.782	31.218	0.1291	0.16466	0.099786
2	131.78	79.64	6.32	13.92	58.853	31.147	0.18795	0.16597	0.100302
2.1	132.4	79.67	6.15	13.06	58.963	31.037	0.06489	0.166751	0.10034
2.2	132.79	80.14	7.34	14.42	58.889	31.111	0.02102	0.167242	0.100932
2.3	132.82	80.32	6.65	14.51	58.836	31.164	0.12558	0.16728	0.101159
2.4	132.73	80.72	7.06	13.98	58.693	31.307	0.09414	0.167166	0.101662
2.5	132.49	79.32	6.85	14.8	59.091	30.909	0.11713	0.166864	0.099899
2.6	134.03	81.65	7.93	13.13	58.65	31.35	0.0845	0.168804	0.102834
2.7	134.13	81.28	7.11	13.24	58.785	31.215	0.11627	0.168929	0.102368
2.8	134.97	82.05	6.93	13.53	58.705	31.295	0.05339	0.169987	0.103338
2.9	135.41	80.89	8.39	15.02	59.148	30.852	0.05749	0.170542	0.101877
3	137.38	82.1	6.77	13.26	59.137	30.863	0.01784	0.173023	0.103401
3.1	138.04	81.79	7.75	14.18	59.354	30.646	-0.0188	0.173854	0.10301
3.2	139.58	81.85	7.78	14.45	59.613	30.387	0.02348	0.175793	0.103086
3.3	138.24	81.17	7.8	14.73	59.578	30.422	-0.06157	0.174106	0.102229
3.4	139.92	79.73	7.98	15.73	60.324	29.676	-0.08456	0.176222	0.100416
3.5	140.66	82.7	7.52	13.88	59.546	30.454	-0.0246	0.177154	0.104156
3.6	140.14	81.81	7.92	14.86	59.723	30.277	0.02044	0.176499	0.103035
3.7	141.5	81.65	7.62	14.55	60.014	29.986	0.00359	0.178212	0.102834
3.8	140.93	82.96	7.43	13.26	59.515	30.485	-0.06087	0.177494	0.104484
3.9	142.54	81.21	7.86	14.83	60.327	29.673	-0.01343	0.179521	0.10228
4	143.64	81.45	7.24	13.84	60.445	29.555	-0.05917	0.180907	0.102582
4.1	143.81	82.1	7.41	15.1	60.278	29.722	-0.03775	0.181121	0.103401
4.2	144.9	81.58	7.71	14.58	60.62	29.38	-0.14387	0.182494	0.102746
4.3	145.58	79.63	7.77	15.73	61.322	28.678	-0.10328	0.18335	0.10029
4.4	144.88	81.88	7.42	14.32	60.526	29.474	-0.02605	0.182469	0.103123
4.5	145.25	79.74	8.33	14.32	61.232	28.768	-0.05885	0.182935	0.100428
4.6	146.64	79.07	8.08	15.9	61.667	28.333	0.0827	0.184685	0.099584
4.7	145.96	80.31	8.01	15.24	61.18	28.82	0.03547	0.183829	0.101146
4.8	146.27	79.75	8.02	14.31	61.401	28.599	-0.01378	0.184219	0.100441
4.9	145.63	78.32	8.64	14.45	61.73	28.27	-0.11426	0.183413	0.09864
5	143.85	79.92	9.06	14.64	60.944	29.056	-0.03567	0.181171	0.100655
5.1	142.71	79.35	9.46	15.53	60.925	29.075	0.00943	0.179736	0.099937
5.2	144.21	79.23	9.7	14.47	61.215	28.785	-0.03407	0.181625	0.099786
5.3	142.68	79.99	9.01	14.39	60.724	29.276	-0.08652	0.179698	0.100743
5.4	142.65	77.67	9.05	15.48	61.434	28.566	0.0958	0.17966	0.097821
5.5	141.96	78.84	8.81	14.63	60.954	29.046	-0.09571	0.178791	0.099295
5.6	141.73	78.8	8.86	15.14	60.926	29.074	0.05333	0.178501	0.099244
5.7	140.68	78.57	9.02	16.64	60.816	29.184	-0.01528	0.177179	0.098955
5.8	140.12	78.95	9.7	15.57	60.599	29.401	0.03199	0.176474	0.099433
5.9	140.42	79.55	8.8	15.2	60.468	29.532	-0.03632	0.176851	0.100189
6	140.26	78.31	8.84	15.54	60.825	29.175	0.04577	0.17665	0.098627
6.1	139.81	78.07	8.78	15.76	60.821	29.179	0.0915	0.176083	0.098325
6.2	139.35	78.54	8.61	15.58	60.593	29.407	0.06522	0.175504	0.098917
6.3	140.13	78.35	8.91	15.77	60.79	29.21	0.04045	0.176486	0.098678
6.4	139.59	78.41	8.95	15.78	60.676	29.324	0.10577	0.175806	0.098753
6.5	139.77	78.72	8.9	15.97	60.61	29.39	0.08737	0.176033	0.099144
6.6	138.33	79.17	8.96	14.58	60.217	29.783	0.06617	0.174219	0.09971
6.7	138.19	78.33	8.38	14.93	60.453	29.547	0.0578	0.174043	0.098652

Table G.15. LDV Data: Forward Position, Middle Depth (01 May 98)

First Stage Rotor LDV Data				Window Ave: On					
Date: 05/01/98				Axial Pos: -.16ct					
N_Ref: 4806				Span Pos: 98%					
Vt= 794				t: .020 in					
Filter Setting: 5-30MHz				freq shifting: -10, 0					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
0	131.66	87.52	7.49	7.86	56.386	33.614	-0.56086	0.165819	0.110227
0.1	133.99	70.92	10.7	20.17	62.109	27.891	0.18499	0.168753	0.08932
0.2	133.25	70.49	10.18	20.47	62.121	27.879	0.02258	0.167821	0.088778
0.3	132.33	71	10.81	20.11	61.784	28.216	0.26297	0.166662	0.089421
0.4	130.39	68.93	10.92	21.45	62.137	27.863	0.10376	0.164219	0.086814
0.5	129.27	66.86	10.35	21.52	62.652	27.348	0.2836	0.162809	0.084207
0.6	128.23	68.54	11.56	19.57	61.874	28.126	0.19311	0.161499	0.086322
0.7	126.83	66.9	10.8	20.37	62.189	27.811	0.07906	0.159736	0.084257
0.8	126.89	65.98	10.94	18.9	62.527	27.473	0.02368	0.159811	0.083098
0.9	125.58	66.84	11.07	20.54	61.974	28.026	0.13072	0.158161	0.084181
1	123.99	67.72	11.04	19.71	61.357	28.643	0.05682	0.156159	0.08529
1.1	124.78	66.99	10.1	19.41	61.772	28.228	-0.03031	0.157154	0.08437
1.2	123.64	66.49	12.66	20.08	61.73	28.27	0.13773	0.155718	0.083741
1.3	123.57	67.82	11.35	18.67	61.239	28.761	0.03846	0.15563	0.085416
1.4	124.91	67.44	11.33	19.39	61.633	28.367	0.00474	0.157317	0.084937
1.5	123.68	65.64	11.57	18.84	62.043	27.957	0.03458	0.155768	0.08267
1.6	121.32	66.82	13.14	19.85	61.156	28.844	0.11808	0.152796	0.084156
1.7	124.13	66.45	11.95	20.36	61.838	28.162	0.13241	0.156335	0.08369
1.8	118.83	67.47	14.49	21.88	60.411	29.589	0.3177	0.14966	0.084975
1.9	121.62	65.9	14.16	20.4	61.548	28.452	0.13647	0.153174	0.082997
2	121.26	68.94	13.9	20.71	60.38	29.62	0.13928	0.15272	0.086826
2.1	123.69	67.94	13.51	19.33	61.219	28.781	0.01909	0.155781	0.085567
2.2	122.92	69.1	14.13	21.32	60.657	29.343	0.09484	0.154811	0.087028
2.3	123.59	67.58	13.54	18.82	61.329	28.671	0.2042	0.155655	0.085113
2.4	124.22	68.67	15.17	20.5	61.068	28.932	0.15335	0.156448	0.086486
2.5	127.04	69.07	16.06	18.94	61.468	28.532	0.12663	0.16	0.08699
2.6	125.28	67.96	16.35	21.17	61.524	28.476	0.17453	0.157783	0.085592
2.7	128.04	69.46	14.82	18.66	61.521	28.479	0.09041	0.161259	0.087481
2.8	129.83	68.84	15.19	19.87	62.066	27.934	0.11459	0.163514	0.0867
2.9	129.6	70.23	14.94	17.47	61.546	28.454	0.19317	0.163224	0.088451
3	127.91	68.36	15.57	19.02	61.877	28.123	0.17939	0.161096	0.086096
3.1	131.32	70.12	15.16	19.21	61.9	28.1	0.09352	0.16539	0.088312
3.2	134.34	70.01	13.09	19.36	62.475	27.525	0.00981	0.169194	0.088174
3.3	134.27	70.22	14.57	17.64	62.392	27.608	0.08944	0.169106	0.088438
3.4	135.83	70.83	14.08	18.2	62.461	27.539	-0.03442	0.171071	0.089207
3.5	136.63	69.65	12.87	19.56	62.989	27.011	0.09915	0.172078	0.08772
3.6	138.69	70.38	12.2	17.2	63.094	26.906	-0.02516	0.174673	0.08864
3.7	137.11	70.6	12.56	17.99	62.757	27.243	0.02296	0.172683	0.088917
3.8	141.33	72.1	10.85	17.65	62.971	27.029	0.04449	0.177997	0.090806
3.9	141.04	71.1	11.06	17.88	63.245	26.755	-0.12863	0.177632	0.089547
4	141.79	70.68	11.18	17.5	63.505	26.495	0.04929	0.178577	0.089018
4.1	142.79	70.86	10.52	18.76	63.605	26.395	0.00534	0.179836	0.089244
4.2	145.41	71.51	9.55	18.28	63.812	26.188	-0.07517	0.183136	0.090063
4.3	145.4	71.74	9.82	18.54	63.738	26.262	-0.078	0.183123	0.090353
4.4	147.19	72.07	8.93	16.86	63.912	26.088	-0.12228	0.185378	0.090768
4.5	145.72	71.93	9.02	17.63	63.73	26.27	-0.15117	0.183526	0.090592
4.6	147.88	71.5	8.52	18.08	64.196	25.804	-0.18072	0.186247	0.09005
4.7	148.54	70.18	8.56	18.51	64.71	25.29	-0.16922	0.187078	0.088388
4.8	147.08	71.59	9.13	18.26	64.046	25.954	-0.19776	0.185239	0.090164
4.9	147.65	72.29	9.02	18.49	63.913	26.087	-0.14677	0.185957	0.091045
5	148.41	70.95	8.03	17.36	64.451	25.549	-0.08652	0.186914	0.089358
5.1	148.26	71.76	8.9	18.73	64.172	25.828	-0.2322	0.186725	0.090378
5.2	146.49	72.07	8.77	18.76	63.802	26.198	-0.20579	0.184496	0.090768
5.3	145.29	72.62	9.74	18.74	63.442	26.558	-0.21309	0.182985	0.091461
5.4	145.21	72.74	8.7	20.93	63.393	26.607	-0.17459	0.182884	0.091612
5.5	143.35	72.52	9.33	19.37	63.165	26.835	-0.1227	0.180542	0.091335
5.6	143.28	72.61	8.92	19.55	63.125	26.875	-0.15516	0.180453	0.091448
5.7	142.24	73.36	9.38	18.68	62.717	27.283	-0.06111	0.179144	0.092393
5.8	142.01	72.51	8.71	19.85	62.95	27.05	-0.02802	0.178854	0.091322
5.9	142.22	74.57	8.59	18.98	62.331	27.669	-0.06465	0.179118	0.093917
6	140.12	73.56	9.48	19.28	62.303	27.697	-0.09376	0.176474	0.092645
6.1	139.73	75.62	8.13	17.92	61.578	28.422	-0.00308	0.175982	0.095239
6.2	139.63	73.74	8.57	19.49	62.161	27.839	0.13048	0.175856	0.092872
6.3	140.07	74.74	8.76	18.66	61.917	28.083	0.08288	0.176411	0.094131
6.4	138.65	74.02	9.11	19.79	61.905	28.095	0.16055	0.174622	0.093224
6.5	138.48	73.6	8.52	19.9	62.011	27.989	0.04075	0.174408	0.092695
6.6	138.51	74.24	9.03	17.52	61.809	28.191	0.04177	0.174446	0.093501
6.7	137.89	74.07	8.88	18.68	61.758	28.242	0.07964	0.173665	0.093287

Table G.16. LDV Data: Forward Position, Outer Depth (01 May 98)

First Stage Rotor LDV Data				Window Ave: On					
Date: 05/01/98				Axial Pos: 0.35ct					
N_Ref: 4797				Span Pos: 88%					
Vt= 796				t: .020 in					
Filter Setting: 10-50, 5-30MHz				freq shifting: -10, 0					
Theta	U-mean	V-mean	U-turb	V-turb	Alpha	90-Alpha	Cuv	X_theta	X_axial
6.5	145.13	76.96	10.17	17.18	62.064	27.936	-0.00492	0.182324	0.096683
6.6	143.82	77.54	10.26	16.96	61.67	28.33	0.00777	0.180678	0.097412
6.7	144.8	76.96	9.73	17.4	62.011	27.989	-0.06563	0.18191	0.096683
6.8	143.17	78.38	10.45	15.46	61.302	28.698	0.03725	0.179862	0.098467
6.9	141.44	77.46	10.31	16.17	61.294	28.706	-0.00667	0.177688	0.097312
7	141.82	77.76	10.63	15.41	61.264	28.736	0.04174	0.178166	0.097688
7.1	141.41	77.49	9.83	15.67	61.278	28.722	0.01897	0.177651	0.097349
7.2	140.77	78.7	11.82	15.64	60.792	29.208	-0.05167	0.176847	0.098869
7.3	140.53	78.05	10.6	15.85	60.953	29.047	-0.00744	0.176545	0.098053
7.4	141.1	78.72	11.27	14.96	60.844	29.156	-0.00379	0.177261	0.098894
7.5	142.75	78.68	11.05	16.31	61.137	28.863	-0.08514	0.179334	0.098844
7.6	138.15	78.73	11.89	14.45	60.322	29.678	-0.02652	0.173555	0.098907
7.7	140.22	77.4	11.97	17.85	61.102	28.898	-0.11758	0.176156	0.097236
7.8	139.73	78.17	11.75	15.46	60.776	29.224	0.00349	0.17554	0.098204
7.9	140.16	78.51	11.62	14.08	60.746	29.254	0.04626	0.17608	0.098631
8	139.61	79.94	10.93	15.63	60.203	29.797	-0.05288	0.175389	0.100427
8.1	139.18	78.91	13.28	13.48	60.448	29.552	-0.01725	0.174849	0.099133
8.2	140.19	78.55	11.9	15.76	60.739	29.261	0.04518	0.176118	0.098681
8.3	138.26	79.18	12.31	15.63	60.201	29.799	-0.05093	0.173693	0.099472
8.4	138.28	79.24	12.15	15.28	60.184	29.816	0.00527	0.173719	0.099548
8.5	140.31	79.03	12.37	16.22	60.61	29.39	-0.12774	0.176269	0.099284
8.6	140.06	77.65	11.73	15.62	60.995	29.005	-0.10562	0.175955	0.09755
8.7	139.09	78.03	12.1	15.49	60.709	29.291	-0.10988	0.174736	0.098028
8.8	139.06	77.12	11.93	17.29	60.987	29.013	-0.12207	0.174698	0.096884
8.9	140.5	77.11	11.51	16.23	61.242	28.758	0.01616	0.176508	0.096872
9	141.26	78.86	10.97	15.46	60.827	29.173	-0.15433	0.177462	0.09907
9.1	139.15	80.94	12.06	13.46	59.816	30.184	-0.10911	0.174812	0.101683
9.2	139.52	79.68	11.21	14.15	60.269	29.731	0.14355	0.175276	0.100101
9.3	139.55	78.57	10.92	15.53	60.621	29.379	-0.0516	0.175314	0.098706
9.4	140.55	77.51	12.91	15.7	61.124	28.876	-0.10769	0.17657	0.097374

Table G.17. LDV Data: Center Position, Inner Depth (01 May 98)

APPENDIX H. COMPUTED ROTOR EXIT PLANE DATA

k	radial distance	alpha	% span	% mdot	vtot/cr	alpha	phi	ps/pr	p0/pr	ts/tr	t0/tr	Mach	ad.effic
1	0	-90	0	0	0.15536	-90	-89.99854	0.74998	0.7631	0.97177	0.9766	0.1576	0.31483
2	0.0000985	-82.95912	0.00985	0.00045	0.11679	-82.95912	0.05496	0.75001	0.75742	0.96959	0.97232	0.11861	0.36273
3	0.0002912	-64.11061	0.02912	0.00242	0.07242	-64.11061	0.01539	0.75006	0.75291	0.96852	0.96957	0.07359	0.39074
4	0.0005413	-9.59177	0.05413	0.00739	0.05089	-9.59177	-0.03622	0.75015	0.75156	0.96604	0.96655	0.05177	0.42681
5	0.0009042	34.49258	0.09042	0.01768	0.08206	34.49258	-0.13857	0.75025	0.75393	0.96229	0.96364	0.08365	0 46898
6	0.0014302	48.97895	0.14302	0.03683	0.12575	48.97895	-0.30246	0.75033	0.75904	0.95789	0.96105	0.12848	0.51423
7	0.0021929	55.0788	0.21929	0.06975	0.16482	55.0788	-0.53341	0.75038	0.76546	0.95345	0.95888	0.1688	0.55922
8	0.0032975	58.41575	0.32975	0.12333	0.197	58.41575	-0.84602	0.75041	0.77211	0.94939	0.95715	0.20219	0.60153
9	0.004897	60.60098	0.4897	0.20733	0.22286	60.60098	-1.25549	0.75043	0.77838	0.94589	0.95582	0.22915	0.63956
10	0.0072085	62.19663	0.72085	0.33554	0.24353	62.19663	-1.76063	0.75047	0.78403	0.94299	0.95485	0.25079	0.67237
11	0.0105442	63.37898	1.05442	0.52769	0.26015	63.37898	-2.29185	0.75055	0.78903	0.94064	0.95418	0.26823	0.70004
12	0.0153442	64.15511	1.53442	0.81251	0.27379	64.15511	-2.68573	0.75069	0.7935	0.93873	0.95372	0.28258	0.72372
13	0.0222257	64.44872	2.22257	1.23303	0.28506	64.44872	-2.74014	0.75092	0.79749	0.93714	0.95339	0.29446	0.74446
14	0.0320376	64.18138	3.20376	1.85478	0.29419	64.18138	-2.34168	0.75123	0.801	0.93586	0.95317	0.30411	0.76232
15	0.0459186	63.33211	4.59186	2.77758	0.30145	63.33211	-1.58692	0.75163	0.80403	0.93488	0.95305	0.31177	0.77703
16	0.0653413	61.9632	6.53413	4.14959	0.30734	61.9632	-0.75162	0.7521	0.80669	0.93413	0.95302	0.31799	0.78923
17	0.0921035	60.2165	9.21035	6.1792	0.31257	60.2165	-0.12544	0.75262	0.80922	0.93346	0.95301	0.32352	0.80075
18	0.1282089	58.27936	12.82089	9.13436	0.31765	58.27936	0.13677	0.75322	0.81181	0.9328	0.95298	0.32889	0.81316
19	0.1755558	56.33136	17.55558	13.31462	0.32243	56.33136	0.0444	0.75396	0.81448	0.93217	0.95296	0.33395	0.82604
20	0.2353854	54.50012	23.53854	18.98034	0.32606	54.50012	-0.27816	0.7549	0.81694	0.9318	0.95306	0.33778	0.83614
21	0.3075458	52.84881	30.75458	26.23648	0.32716	52.84881	-0.64597	0.75608	0.81862	0.93202	0.95343	0.33888	0.83802
22	0.3898437	51.38651	38.98437	34.90114	0.32395	51.38651	-0.86939	0.75742	0.81875	0.93317	0.95416	0.33535	0.82545
23	0.4779231	50.0649	47.79231	44.43405	0.31456	50.0649	-0.81461	0.75879	0.81647	0.93553	0.95532	0.32522	0.79382
24	0.5660036	48.72149	56.60036	54.01362	0.29745	48.72149	-0.43954	0.75999	0.8113	0.9392	0.9569	0.30693	0.74314
25	0.6483053	46.93533	64.83053	62.78003	0.27243	46.93533	0.23284	0.76097	0.80367	0.944	0.95884	0.28039	0.67989
26	0.720471	43.8221	72.0471	70.12726	0.24227	43.8221	1.21615	0.76183	0.79531	0.94928	0.96102	0.24865	0.61535
27	0.7803058	38.12332	78.03058	75.86184	0.21432	38.12332	2.65166	0.76284	0.78886	0.9541	0.96329	0.21942	0.56037
28	0.8276587	29.54634	82.76587	80.14642	0.19864	29.54634	4.52954	0.76409	0.78636	0.95766	0.96555	0.20298	0.51913
29	0.8637684	20.30036	86.37684	83.31182	0.19822	20.30036	6.18799	0.76506	0.78721	0.95971	0.96757	0.20234	0.49087
30	0.8905344	12.46048	89.05344	85.68281	0.20316	12.46048	6.78878	0.7657	0.78897	0.96092	0.96917	0.20725	0.47079
31	0.9099601	5.74451	90.99601	87.49698	0.20452	5.74451	6.19076	0.76669	0.79028	0.9624	0.97077	0.20848	0.44948
32	0.9238429	-0.0977	92.38429	88.90458	0.20505	-0.0977	4.92288	0.76759	0.79128	0.96389	0.9723	0.20885	0.42816
33	0.9336562	-4.15661	93.36562	89.99778	0.20994	-4.15661	3.7093	0.76783	0.79267	0.96469	0.97351	0.21375	0.41247
34	0.9405392	-5.92609	94.05392	90.83712	0.21878	-5.92609	2.9262	0.76765	0.79465	0.96468	0.97426	0.22274	0.40499
35	0.94534	-6.02222	94.534	91.46902	0.22825	-6.02222	2.53194	0.76737	0.79679	0.96408	0.9745	0.23246	0.40578
36	0.9486767	-5.37274	94.86767	91.9342	0.23602	-5.37274	2.37612	0.76711	0.79861	0.96326	0.9744	0.24048	0.4113
37	0.950988	-4.60695	95.0988	92.26965	0.24155	-4.60695	2.3469	0.76691	0.79994	0.96257	0.97424	0.2462	0.41696
38	0.9525878	-3.98802	95.25878	92.50778	0.24531	-3.98802	2.36877	0.76676	0.80086	0.96211	0.97414	0.25009	0.42058
39	0.9536924	-3.56023	95.36924	92.67508	0.24793	-3.56023	2.39648	0.76667	0.80152	0.96183	0.97413	0.2528	0.42236
40	0.9544551	-3.28473	95.44551	92.79187	0.24986	-3.28473	2.41211	0.76661	0.80202	0.96165	0.97414	0.25479	0.4233
41	0.9549811	-3.11026	95.49811	92.87312	0.2513	-3.11026	2.41676	0.76657	0.8024	0.96151	0.97414	0.25628	0.42415
42	0.9553448	-2.99251	95.53448	92.92952	0.25235	-2.99251	2.41856	0.76654	0.80268	0.96138	0.97412	0.25737	0.42518
43	0.9555948	-2.90457	95.55948	92.96933	0.2531	-2.90457	2.41968	0.76652	0.80288	0.96127	0.97408	0.25815	0.42626
44	0.9557878	-2.84507	95.57878	92.99705	0.25359	-2.84507	2.42149	0.76651	0.80301	0.9612	0.97406	0.25866	0.42699
45	0.9558855	-2.79923	95.58855	93.01547	0.25389	-2.79923	2.42504	0.7665	0.80309	0.96115	0.97404	0.25897	0.42746
46	0.9559837	-2.74541	95.59837	93.04699	0.25421	-2.74541	2.42885	0.76648	0.80317	0.96103	0.97395	0.25931	0.42909
47	0.9565206	-2.56355	95.65206	93.13898	0.25541	-2.56355	2.44154	0.76644	0.80349	0.96076	0.97381	0.26057	0.43216
48	0.9577637	-2.03444	95.77637	93.37547	0.25905	-2.03444	2.47181	0.76633	0.80449	0.96007	0.97349	0.26438	0.4399
49	0.9608718	-0.71917	96.08718	93.93501	0.26733	-0.71917	2.61209	0.76611	0.80685	0.95843	0.97272	0.27307	0.45864
50	0.9675166	1.52727	96.75166	95.04134	0.27939	1.52727	2.77748	0.76564	0.81029	0.95622	0.97184	0.28571	0.48282
51	0.977943	4.14735	97.7943	96.65221	0.2877	4.14735	2.71968	0.76495	0.81238	0.95474	0.9713	0.29444	0.49798
52	0.9883689	6.6478	98.83689	98.25707	0.2814	6.6478	2.43416	0.76429	0.80956	0.95547	0.97131	0.28789	0.48984
53	0.9950138	8.71963	99.50138	99.32412	0.25256	8.71963	2.07648	0.76376	0.7999	0.95932	0.97207	0.25786	0.45192
54	0.9981218	9.99069	99.81218	99.80512	0.20055	9.99069	1.81397	0.76315	0.78564	0.96552	0.97357	0.2041	0.39682
55	0.9993649	10.35494	99.93649	99.95979	0.1302	10.35494	1.70004	0.76247	0.77183	0.97148	0.97487	0.13209	0.35227
56	0.9999018	9.8434	99.99018	99.99555	0.0561	9.8434	1.68314	0.76201	0.76374	0.9741	0.97473	0.05685	0.34099
57	1	0	100	100	0	0	0	0.76135	0.76135	0.9791	0.9791	0	0.27883

Table H.1. Rotor Exit Plan Data

APPENDIX I. SECONDARY PROGRAM

The SECONDARY program takes the grid file and the solution file and creates a plane grid with a solution file. This is convenient for viewing a flat exit plan at a given location behind the leading edge of the blade.

```
c***********************************************************************
c     pxy.f reads rvc3d files & writes ascii files for plotxy
c     unit 1  = input xyz file
c     unit 3  = input q file
c     unit 6  = input error im-imax.or.jm-jmax.or.km-kmax.ne.0
c     unit 29 = output secondary.q
c     unit 30 = output secondary.x
c***********************************************************************
      parameter(ni=350,nj=51,nk=72)
      real x(ni,nj,nk),y(ni,nj,nk),z(ni,nj,nk)
      real qq(5,ni,nj,nk),resd(5000,5)
      real u(ni,nj,nk),v(ni,nj,nk),w(ni,nj,nk)
      real xpp(2*nj,nk),ypp(2*nj,nk),zpp(2*nj,nk)
      real upp(2*nj,nk),vpp(2*nj,nk),wpp(2*nj,nk)
      real xps(2*nj,nk),yps(2*nj,nk),zps(2*nj,nk)
      real ups(2*nj,nk),vps(2*nj,nk),wps(2*nj,nk)
      real x2d(2*nj,nk),y2d(2*nj,nk),z2d(2*nj,nk),q2d(5,2*nj,nk)
      real x1d(2*nj),y1d(2*nj),z1d(2*nj),q1d(5,2*nj)
      real u1d(2*nj),v1d(2*nj),w1d(2*nj)
      integer imd2,kmd2
c***********************************************************************
c     read grid coordinates
c***********************************************************************
      read(1)im,jm,km
      read(1)(((x(i,j,k),i=1,im),j=1,jm),k=1,km),
     1       (((y(i,j,k),i=1,im),j=1,jm),k=1,km),
     2       (((z(i,j,k),i=1,im),j=1,jm),k=1,km)
c***********************************************************************
c     read restart file
c***********************************************************************
      read(3)imax,jmax,kmax
      read(3)fsmach,alpha,re,time
c
      icheck=iabs(im-imax)+iabs(jm-jmax)+iabs(km-kmax)
      if(icheck.ne.0)then
      write(6)im,jm,km,imax,jmax,kmax
      stop
      endif
c
      read(3)((((qq(l,i,j,k),i=1,im),j=1,jm),k=1,km),l=1,5)
c
c     additional residual data
      read(3)itl,iil,phdeg,ga,om,nres,dum,dum,dum,dum
      read(3)((resd(nr,l),nr=1,nres),l=1,5)
c
      print *,'Done reading fort.3'
c
c     non-dimensionalize the velocity field wrt Vref
```

```
c
      imd2=im/2
      kmd2=km/2
      u1=qq(2,imd2,jm,kmd2)/qq(1,imd2,jm,kmd2)
      v1=qq(3,imd2,jm,kmd2)/qq(1,imd2,jm,kmd2)
      w1=qq(4,imd2,jm,kmd2)/qq(1,imd2,jm,kmd2)
      vref=sqrt(u1**2+v1**2+w1**2)
      print *,' Vref = ',vref
c
c     calculate the velocity field
c
      do i=1,im
         do j=1,jm
            do k=1,km
               u(i,j,k)=qq(2,i,j,k)/qq(1,i,j,k)/vref
               v(i,j,k)=qq(3,i,j,k)/qq(1,i,j,k)/vref
               w(i,j,k)=qq(4,i,j,k)/qq(1,i,j,k)/vref
            enddo
         enddo
      enddo
      print *,u(im,jm,km),v(im,jm,km),w(im,jm,km)
c***********************************************************************
c***********************************************************************
c
c
c     find the xmin and xmax grid points corresponding to the min and
max
c     axial location of the blade
c
      xmin=10.
      xmax=0.
      k=1
c
      istart=itl
      ifinit=im-itl+1
      do i=istart,ifinit
         if(x(i,1,k).le.xmin)then
            imin=i
            xmin=x(i,1,k)
         endif
c
         if(x(i,1,k).ge.xmax)then
            imax=i
            xmax=x(i,1,k)
         endif
      enddo
      print *,'xmin=',xmin,'xmax=',xmax
c
c     find the grid no. at 130% chord
c
      chord=abs(xmax-xmin)
      print *,'chord=',chord
      chlr=1.685147*chord+xmin
      print *,'chlr=',chlr
c
      do k=1,km
         do j=1,jm
            do i=1,imd2-1
               chlo=x(i,j,k)
               if(chlo.le.chlr)then
                  d=x(i-1,j,k)-x(i,j,k)
                  xpp(j,k)=chlr
```

```
                  ypp(j,k)=y(i-1,j,k)+
     #(x(i-1,j,k)-chlr)*(y(i,j,k)-y(i-1,j,k))/d
                  zpp(j,k)=z(i-1,j,k)+
     #(x(i-1,j,k)-chlr)*(z(i,j,k)-z(i-1,j,k))/d
                  upp(j,k)=u(i-1,j,k)+
     #(x(i-1,j,k)-chlr)*(u(i,j,k)-u(i-1,j,k))/d
                  vpp(j,k)=v(i-1,j,k)+
     #(x(i-1,j,k)-chlr)*(v(i,j,k)-v(i-1,j,k))/d
                  wpp(j,k)=w(i-1,j,k)+
     #(x(i-1,j,k)-chlr)*(w(i,j,k)-w(i-1,j,k))/d
               go to 1000
               endif
            enddo
 1000       do i=im,imd2+1,-1
               chlo=x(i,j,k)
               if(chlo.le.chlr)then
                  d=x(i+1,j,k)-x(i,j,k)
                  xps(j,k)=chlr
                  yps(j,k)=y(i,j,k)+
     #(chlr-x(i,j,k))*(y(i+1,j,k)-y(i,j,k))/d
                  zps(j,k)=z(i,j,k)+
     #(chlr-x(i,j,k))*(z(i+1,j,k)-z(i,j,k))/d
                  ups(j,k)=u(i,j,k)+
     #(chlr-x(i,j,k))*(u(i+1,j,k)-u(i,j,k))/d
                  vps(j,k)=v(i,j,k)+
     #(chlr-x(i,j,k))*(v(i+1,j,k)-v(i,j,k))/d
                  wps(j,k)=w(i,j,k)+
     #(chlr-x(i,j,k))*(w(i+1,j,k)-w(i,j,k))/d
                  go to 1001
                  endif
               enddo
 1001       continue
         enddo
      enddo
c
      print *,"Finished interpolating"
c
c     write plot3d 3d-file
c
      i2d=2*jm-1
      j2d=km
      write(29)i2d,j2d,1
      write(30)i2d,j2d,1
      write(31)i2d,1,1
      write(32)i2d,1,1
      write(29)fsmach,alpha,re,time
      write(31)fsmach,alpha,re,time
      i=0
      do j=jm,1,-1
         i=i+1
         do k=1,km
            x2d(i,k)=xpp(j,k)
            y2d(i,k)=ypp(j,k)
            z2d(i,k)=zpp(j,k)
            q2d(1,i,k)=1.
            q2d(2,i,k)=upp(j,k)
            q2d(3,i,k)=vpp(j,k)
            q2d(4,i,k)=wpp(j,k)
            q2d(5,i,k)=1.
         enddo
      enddo
c
```

```
      do j=2,jm
         i=i+1
         do k=1,km
            x2d(i,k)=xps(j,k)
            y2d(i,k)=yps(j,k)
            z2d(i,k)=zps(j,k)
            q2d(1,i,k)=1.
            q2d(2,i,k)=ups(j,k)
            q2d(3,i,k)=vps(j,k)
            q2d(4,i,k)=wps(j,k)
            q2d(5,i,k)=1.
         enddo
      enddo
c
      measure=5.0
      do i=1,i2d
         do j=1,j2d
            r=sqrt(y2d(i,j)**2+z2d(i,j)**2)
            if(measure.le.r)then
               d=y2d(i,j-1)-y2d(i,j)
               x1d(i)=chlr
               y1d(i)=measure
               z1d(i)=z2d(i,j-1)+
     #(y2d(i,j-1)-measure)*(z2d(i,j)-z2d(i,j-1))/d
               u1d(i)=q2d(2,i,j-1)+
     #(y2d(i,j-1)-measure)*(q2d(2,i,j)-q2d(2,i,j-1))/d
               v1d(i)=q2d(3,i-1,j)+
     #(y2d(i,j-1)-measure)*(q2d(3,i,j)-q2d(3,i,j-1))/d
               w1d(i)=q2d(4,i-1,j)+
     #(y2d(i,j-1)-measure)*(q2d(4,i,j)-q2d(4,i,j-1))/d
               q1d(1,i)=1
               q1d(2,i)=u1d(i)
               q1d(3,i)=v1d(i)
               q1d(4,i)=w1d(i)
               q1d(5,i)=1
               go to 2001
            endif
         enddo
 2001    continue
      enddo
c
      write(30)((x2d(i,j),i=1,i2d),j=1,j2d),
     #          ((y2d(i,j),i=1,i2d),j=1,j2d),
     #          ((z2d(i,j),i=1,i2d),j=1,j2d)
      write(29)(((q2d(l,i,j),i=1,i2d),j=1,j2d),l=1,5)
      write(32)((x1d(i),i=1,i2d),(y1d(i),i=1,i2d),
     #          (z1d(i),i=1,i2d))
      write(31)((q1d(l,i),i=1,i2d),l=1,5)
      print *,"Finished"

c**********************************************************************
c**********************************************************************
c**********************************************************************
      stop
      end
```

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